TIMES

INTERIM DEVELOPMENT REPORT

FOR

DESIGN AND DEVELOPMENT OF IMPROVED WATERTIGHT COAXIAL CABLE

by David A. Peterson

TIMES WIRE & CABLE
division of
THE INTERNATIONAL SILVER COMPANY
WALLINGFORD, CONNECTICUT, U.S.A.

TIMES WIRE AND CABLE
DIVISION OF
The International Silver Company

MANUFACTURERS OF ENGINEERED WIRE AND CABLE PRODUCTS
WALLINGFORD, CONNECTICUT

May 7, 1963

To: Chief, Bureau of Ships
Main Navy Building
Washington, D.C.

Via: Inspector of Naval Material, Bridgeport, Connecticut

Subject: Letter of transmittal, 2nd Progress Report, Contract No NObsr-87678, Project Seri-l No. SF0060306, Task 2266

This report is submitted in accordance to BurShips Contract NObsr-87678.

The watertightness techniques developed in Contract NObsr-87678 and improved in this contract have been successfully used in the manufacture of modified watertight versions of RG-57/U and RG-14/U for the Underwater Sound Laboratory and a special watertight 95 ohm cable for a Navy Project at the University of Denver. All cables were watertight at 1000 psi. We presently feel we will shortly be able to offer you a cable construction that will be watertight at pressures greater than 2500 psi.

If any information is desired before the next reporting date, please let me know.

Sincerely,

TIMES WIRE & CABLE DIVISION

David A. Peterson

David A. Peterson
Staff Engineer

UNCLASSIFIED

INTERIM DEVELOPMENT REPORT

FOR

DESIGN AND DEVELOPMENT OF IMPROVED

WATERTIGHT COAXIAL CABLE

This report covers the period of October 1, 1962 to December 31, 1962

by

TIMES WIRE AND CABLE DIVISION

THE INTERNATIONAL SILVER COMPANY, INC.

358 HALL AVENUE

WALLINGFORD, CONNECTICUT

ENG. REPORT NO. 222-B

for

NAVY DEPARTMENT BUREAU OF SHIPS ELECTRONICS DIVISION

CONTRACT NO: NObsr-87678, PROJECT SERIAL NO. SF0060306, TASK 2266

JUNE 29, 1962

UNCLASSIFIED

Copy No.: 22

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ABSTRACT

The results of attenuation, VSWR, watertightness, stability, pliability and other tests on 33 various sample constructions show RG-214/U, RG-217/U and RG-218/U can be redesigned to be watertight at 1000 psi and have less attenuation, better attenuation stability, be more pliable, and have better abrasion resistance than the standard designed cable. The new designs would still be compatible with the connectors presently used on the standard cables. The size of the cable can also be decreased, if desired, but then the connector would require redesign. The results presented show the technique used to manufacture the braid watertight is good for pressures greater than 2500 psi. The attenuation on all RG coaxial cable can be decreased by an improved braid design. RG-214/U, which is considered one of the better designed RG cable, has better than 20% less attenuation from 10 MC to 10 GC with the improved braid design. The pliability of a cable depends almost completely upon its jacket stiffness. Pliability results are presented that show polyurethane jacketed cables are vastly more pliable at 80°F, 0°F and -40°F than polyvinylchloride or polyethylene jacketed cables. The program for the next interval is presented.

PART I

1.1 PURPOSE

1.1.1 Contract - The purpose of the contract is to design and manufacture improved versions of RG-214/U, RG-217/U and RG-218/U which are physically smaller, more flexible, are watertight along their axis at 1000 psi and, if possible, with decreased attenuation. The development shall be carried out in three phases, concluding in the manufacture and shipment of 5000 feet of each of the improved cables.

1.1.2 Phase I - The purpose of Phase I is to manufacture and test lengths of RG-214/U, RG-217/U and RG-218/U and various sample constructions of these cables manufactured with new techniques and materials. The test results shall be used to evaluate the effect of the new techniques and materials upon attenuation, impedance, abrasion resistance, flammability and pliability.

1.1.3 Phase II - The purpose of Phase II is to manufacture and test cables designed from the information obtained from Phase I and to apply the techniques for production of watertight coaxial cables developed under Contract NObsr-81424 to these cable designs. The purpose is also to develop new watertightness techniques if necessary.

1.1.4 Phase III - The purpose of Phase III is to evaluate all the data obtained from Phase I and II and design improved watertight versions of RG-214/U, RG-217/U and RG-218/U. This phase will also include the manufacture and shipment of 5000 feet of each of the improved watertight cables to an agency to be designated by the Chief, Bureau of Ships.

1.1.5 Report - The purpose of this report is to present the information gathered and the progress made during the reporting period of October 1, 1962 to December 31, 1962.

1.2 GENERAL FACTUAL DATA

1.2.1 Identification of technicians - The following list presents the engineering personnel contributing to the contract and their man-hours performed during this reporting period.

David A. Peterson	Engineer	386.5 hours
Norbert Ostrowski	Engineering Aide	177.5 hours
John Palmero	Technician	186.9 hours
Larry Racow	Technician	333.5 hours

1.2.2 Test procedures - The following paragraph describes the only change made to the test procedures discussed in paragraph 1.2.2 of the first interim progress report.

1.2.2.1 Pliability - The pliability test (paragraph 1.2.2.11 of the first interim progress report) was devised to give comparable values to the pliability of the cable samples at 20°C, 0°C, -20°C and -40°C. The equipment and test specimen was arranged as illustrated in figure 1.1. The weight used to bend the sample was recorded and the time for the sample to bend ninety degrees (to a vertical position) was measured and recorded.

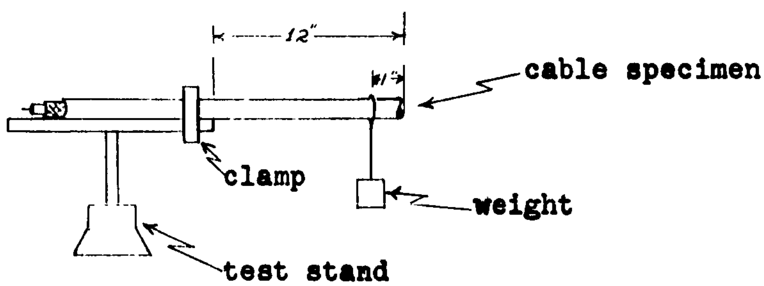


figure 1.1 - Pliability test equipment and specimen layout.

1.3 DETAIL FACTUAL DATA

1.3.1 Sample description - Table 1.1 pages 4 - 8, presents descriptions of the sample constructions. The description of the samples of Phase I are repeated to aid in the discussion of the test results. Three new samples studied in Phase I are also described.

Table 1.1 Description of sample constructions

Sample Numbers	Manufacturing Instructions	Description	Construction			
			Inner Conductor	Dielectric	Outer Conductor	Jacket
1	MI-1069	RG 214/U	7 strands of 0.0296" silver plated copper	polyethylene dia: 0.285"	Two braids of 34 ga. silver plated copper	Non-contaminating polyvinylchloride dia: 0.425"
2	MI-1159	RG 217/U	Bare copper dia: 0.106"	polyethylene dia: 0.370"	Braid of 33 ga. bare copper	Non-contaminating polyvinylchloride dia: 0.545"
3	MI-1071	RG 218/U	Bare copper dia: 0.195"	polyethylene dia: 0.680"	Braid of 30 gauge bare copper	Non-contaminating polyvinylchloride dia: .870"
4	MI-1236	Watertight construction of RG-214/U	Same as sample #1		Two braids of 34 ga. silver plated copper with DC 274	Polyethylene dia: 0.425"
5	MI-1235	Watertight construction of RG-217/U	Silver plated copper dia: 0.106"	Same as sample #2	Braid of 36ga silver plated copper with DC 274	Polyethylene dia: 0.545"
6	MI-1244	Watertight construction of RG-218/U	Same as sample #3		Braid of 30 ga. bare copper with DC 274	Polyethylene dia: 0.870"
7	MI-9541	Silver plated 36 ga. shield over RG-217/U core with polyethylene jacket	Same as sample #2		Braid of 36 ga. silver plated copper	Same as sample #5
8	MI-9542	Bare copper 36ga shield over RG-217/U core with thin polyethylene jacket	Same as sample #2		Braid of 36 ga. bare copper	Polyethylene dia: 0.450"

Table 1.1 (cont.) Description of sample construction

Sample Number	Manufacturing Instruction	Description	Construction			
			Inner Conductor	Dielectric	Outer Conductor	Jacket
9	MI-9543	RG-217/U Size with stranded (7) center conductor	7 strands of 0.036 bare copper	Same as sample #7		
10	MI-9544	RG-217/U Size with stranded (19) center conductor	19 strands of 0.0231 bare copper	Same as sample #7		
11	MI-9545	RG-217/U Size with loose braided center conductor	Braid of 36 ga. silvered copper (10.8 picks) over 0.090" poly-ethylene bead	Same as sample #7		
12	MI-9546	RG-217/U Size with tight braided center conductor	Braid of 36 ga. silvered copper (30.3 picks) over 0.090" poly-ethylene bead	Same as sample #7		
13	MI-9547	Cellular poly-ethylene dielectric over RG-217/U Size Conductor	Same as sample #2	Cellular polyethylene dia: 0.300"	Braid of 36 ga. silvered copper	Polyethylene dia: 0.475"
14	MI-9548	Cellular poly-ethylene dielectric to RG-217/U size but with larger cen-ter conductor	Bare copper dia: 0.128"	Cellular polyethylene dia: 0.370"	Same as sample #7	
15	MI-9549	Elastomeric polyethylene dielectric and jacket	Same as sample #7	Elastomeric polyethylene dia: 0.370"	Same as sample #7	Elastomeric polyethylene dia: 0.545"
16	MI-9550	Modified high mo-lecular weight polyethylene dielectric and jacket	Same as sample #7	~~Modified high molecular weight poly-ethylene dia: 0.370"~~ CANCELLED	Same as sample #7	Modified high molecular weight poly-ethylene dia: 0.370"

Sample Number	Manufacturing Instruction	Description	Construction			
			Inner Conductor	Dielectric	Outer Conductor	Jacket
17	MI-9551	RG-217/U core with flat copper braid and polyethylene jacket	Same as sample #7		Braid of flat copper	Polyethylene dia: 0.500"
18	MI-9552	RG-217/U size with polyurethane jacket	Same as sample #7 ------------			Polyurethane dia: 0.545"
19	MI-9553	RG-217/U size with high molecular weight polyethylene jacket	CANCELLED Same as sample #7 --------------			Modified high molecular weight polyethylene dia: 0.545"
20	MI-9554	RG-217/U size with elastomeric polyethylene jacket	Same as sample #7 -------------			Elastomeric polyethylene dia: 0.545"
21	MI-9555	RG-214/U size with single braid of 36 ga. silver plated copper	Same as sample #1		Braid of 36ga silvered copper	Polyethylene dia: 0.405"
22	MI-9556	RG-218/U size with braid of 36 ga. silver plated copper	Same as sample #3		Braid of 36 ga. silvered copper	Polyethylene dia: 0.850"
23	MI-9558	Tinned copper 36ga shield over RG-217/U core with polyethylene jacket	Same as sample #7		Braid of 36 ga. tinned copper	Same as sample #7
24	MI-9559	Silver plated 36 ga. shield over RG-217/U core with Type I Jacket	Same as sample #7 ------------			Type I polyvinylchloride dia: 0.545"

Table 1.1(cont.) Description of sample construction

Sample Number	Manufacturing Instruction	Description	Construction: Inner Conductor	Construction: Dielectric	Construction: Outer Conductor	Construction: Jacket
25	MI-9560	Silver plated 36 ga. shield over RG-217/U core with Type IIa jacket	Same as sample #7 -----------			Type IIa polyvinyl-chloride dia: 0.545"
26	MI-9561	Bare copper 36 ga. shield over RG-217/U core with Type I jacket	Same as sample #7		Same as sample #8	Same as sample #24
27	MI-9562	Bare copper 36 ga. shield over RG-217/U core with Type IIa jacket	Same as sample #7		Same as sample #8	Same as sample #25
28	MI-9563	Tinned copper 36 ga. shield over RG-217/U core with Type I jacket	Same as sample #7		Same as sample #23	Same as sample #24
29	MI-9564	Tinned copper 36 ga. shield over RG-217/U core with Type IIa jacket	Same as sample #7		Same as sample #23	Same as sample #25
30	MI-9571	RG-214/U size with silver plated flat braid	Same as sample #1		Braid of flat silver plated copper	Same as sample #1
31	MI-9587	RG-217/U size with 35.3° braid angle	Same as sample #7		Braid of 36ga silver plated with 10 ends and 7.14 picks	Same as sample #7
32	MI-9588	RG-217/U size with 19.7° braid angle	Same as sample #7		Braid of 36 ga silver plated with 10 ends and 3.6 picks	Same as sample #7

Table 1.1 (Cont.) Description of sample constructions

Sample Number	Manufacturing Instruction	Description	Construction: Inner Conductor	Construction: Dielectric	Construction: Outer Conductor	Construction: Jacket
33	MI-9592	RG-217/U size with 18^{o} braid angle and high coverage	Same as sample # 7		Braid of 36 ga. silver plate with 18 ends and 3.28 picks	Same as sample # 7

1.3.2 <u>Sample discussion</u> - Samples 16 and 19 were canceled because the modified high molecular weight polyethylene is no longer available. Through an identification error the first interim progress report incorrectly reported sample 9 was manufactured and ready for test. The sample has now been manufactured and will be tested with other phase II cables. The first run of sample 14 was rejected because its dielectric was extruded to the same dimension as sample 13. The impedance resulting from this error negated the intent of the sample. The sample is being rerun and will be available for test during the next reporting period. Sample 31, 32 and 33 were manufactured to examine the effect of the braid angle on the attenuation braid factor. The attenuation of these three samples were measured but no other tests will be performed. The cables with polyethylene jackets were not subjected to the abrasion resistance test since the polyethylene waxes the abrasive rod and makes the test meaningless.

1.3.3 <u>Attenuation test results</u> - The results of attenuation measurements on the samples are presented in table 1.2 on page 9 and in graphs 1.1 to 1.29. The graphs compare the measured results at 10, 50, 100, 250 and 500 megacycles and 1.7, 3.0, 5.0, 8.0 and 10.0 gigacycles to a curve drawn from calculated results at 10, 100, 1000 and 10,000 megacycles. The calculated results were obtained with the following expressions:

$a_t = a_c + a_d$ (db/100 ft)

$a_t \equiv$ total attenuation (db/100 ft)

$a_c \equiv$ conductor losses $= (4.33)\,(10)^{-4} \frac{\sqrt{f}}{Z}\left(\frac{1}{d}+\frac{F}{D}\right)$ (db/100 ft)

$a_d \equiv$ dielectric losses $= (8.85)\,(10)^{-7}\,\pi\, f d_f \sqrt{\epsilon}$ (db/100 ft)

$F_{bd} \equiv$ braid factor $= \frac{8D + 16d_s}{CNd_s}$

$f \equiv$ frequency (cycles/second)

$Z \equiv$ characteristic impedance of cables (ohms)

$d \equiv$ diameter of center conductor (inches)

$D \equiv$ diameter of dielectric (inches)

$d_f \equiv$ dissipation factor of dielectric

$\epsilon \equiv$ dielectric constant of dielectric

$d_s \equiv$ diameter of braid strand (inches)

$C \equiv$ number of carriers in braid

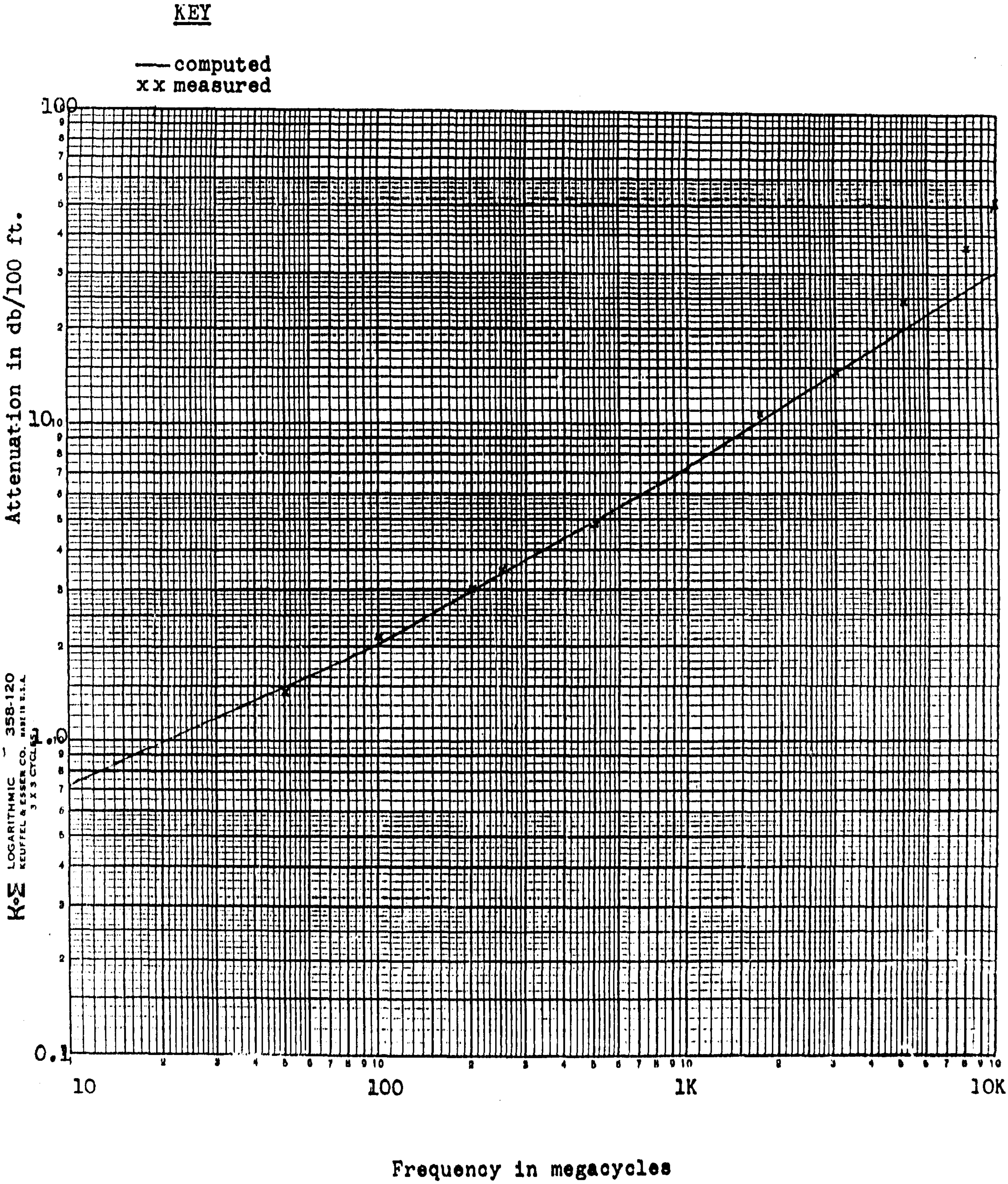
$N \equiv$ number of ends in braid

Text continued on Page 39

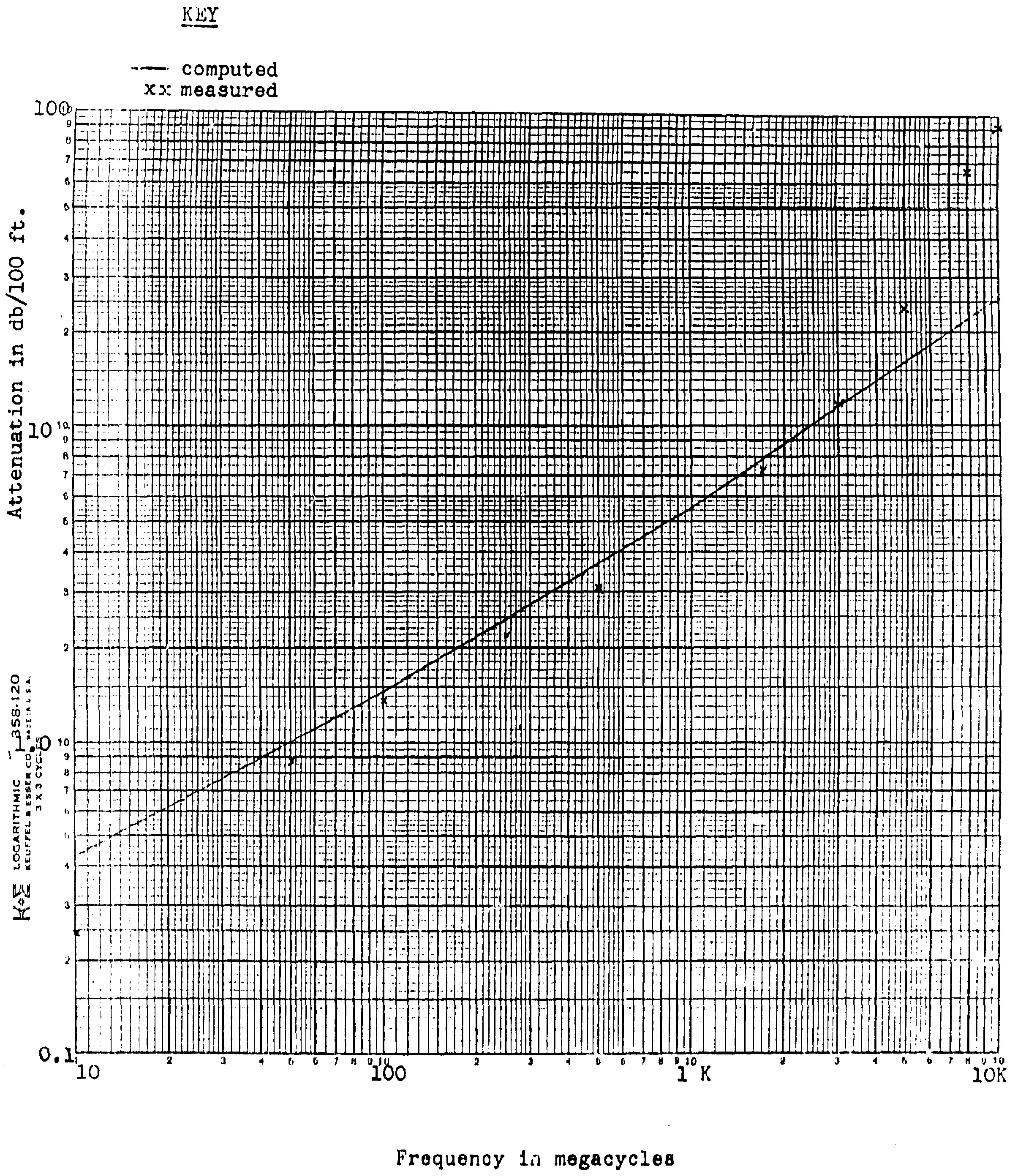
Table 1.2 - Attenuation Test Results (db/100 ft)

Sample No.	Frequency in Megacycles									
	10	50	100	250	500	1700	3000	5000	8000	10,000
1	---	1.46	2.18	3.46	4.84	10.82	14.70	24.22	36.33	50.75
2	6.25	0.79	1.38	2.20	3.05	7.24	11.75	24.00	65.77	92.40
3	0.17	0.40	0.71	1.54	1.90	5.23	9.55	18.90	47.60	64.70
4	0.68	1.52	2.24	3.72	5.40	14.30	23.60	35.40	57.00	71.30
5	0.60	0.92	1.60	2.60	3.72	10.10	13.60	23.50	62.20	81.20
6	0.59	0.79	0.98	1.57	2.36	6.43	9.92	18.90	45.40	64.70
7	---	1.04	1.56	2.56	3.52	8.20	11.30	16.20	23.90	28.60
8	---	1.10	1.60	2.60	3.64	9.68	12.00	20.70	57.70	111.5
9	---	---	---	---	---	---	---	---	---	---
10	0.59	1.33	1.95	3.55	5.08	10.00	14.95	21.50	38.20	72.40
11	---	1.55	2.39	3.78	5.22	12.40	18.30	24.30	39.20	42.60
12	---	1.60	4.20	6.00	4.80	12.10	18.50	24.20	36.10	41.20
13	9.36	1.24	1.72	3.00	4.00	8.00	12.00	14.50	22.20	27.00
14	---	---	---	---	---	---	---	---	---	---
15	4.50	9.00	20.00	47.50	75.00	176.4	250.0	340.0	461.6	600.0
16	---	---	---	---	---	---	---	---	---	---
17	0.48	0.80	1.28	2.16	2.96	8.0	10.2	13.4	25.7	30.2
18	0.44	1.13	1.52	2.57	3.66	8.56	10.10	16.00	25.40	38.20
19	---	---	---	---	---	---	---	---	---	---
20	0.40	1.00	1.56	2.52	3.56	9.16	12.30	17.70	33.60	65.20
21	0.64	1.24	2.12	3.40	4.64	10.70	13.60	18.50	27.60	31.0
22	0.28	0.40	0.88	1.52	2.08	5.36	9.32	13.4	16.30	22.6
23	---	1.10	1.60	2.54	3.60	8.95	12.00	18.50	39.50	85.00
24	0.45	1.17	1.62	2.43	3.60	8.10	15.15	15.60	27.00	44.50
25	0.56	1.00	1.56	2.64	3.68	8.74	12.30	14.40	25.00	45.3
26	0.52	1.08	1.68	2.72	3.76	9.15	12.90	17.50	46.60	120.2
27	0.52	1.08	1.72	2.80	3.84	8.64	12.00	18.80	45.70	119.0
28	0.52	1.00	1.60	2.60	3.80	8.96	13.20	16.10	36.40	94.5
29	0.52	1.00	1.60	2.56	3.72	8.96	13.60	15.10	40.00	76.00
30	---	1.20	1.72	2.78	3.8	8.34	11.54	17.38	21.40	24.76
31	.422	.986	1.37	2.32	3.35	7.39	10.25	14.6	25.7	32.6
32	.404	.942	1.35	2.24	3.14	7.15	9.84	11.4	19.3	22.2
33	.398	.885	1.33	2.21	3.10	7.44	9.59	14.08	23.2	27.3

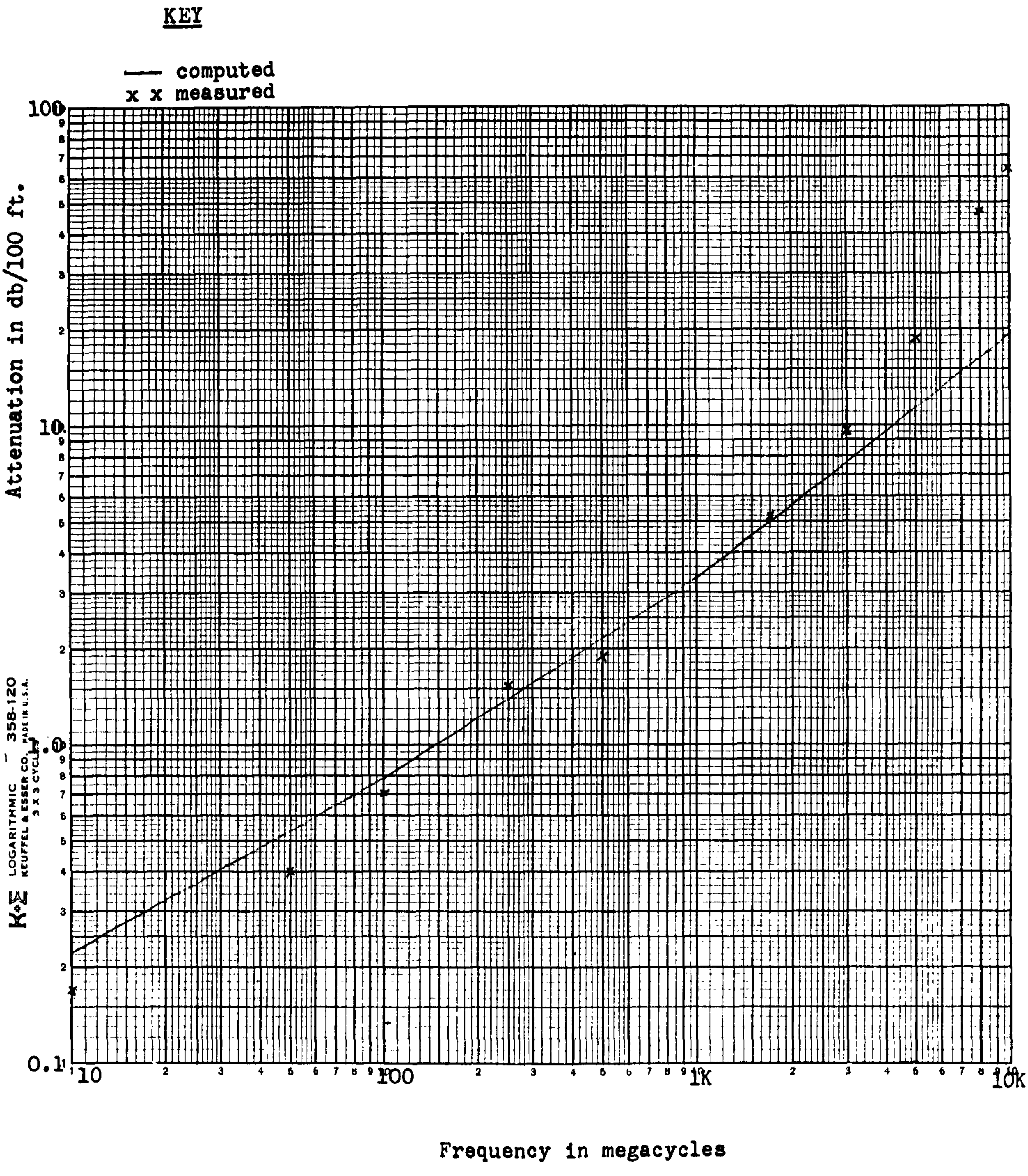
Graph 1.1 - Computed and measured attenuation of sample 1



Graph 1.2 - Computed and measured attenuation of sample 2



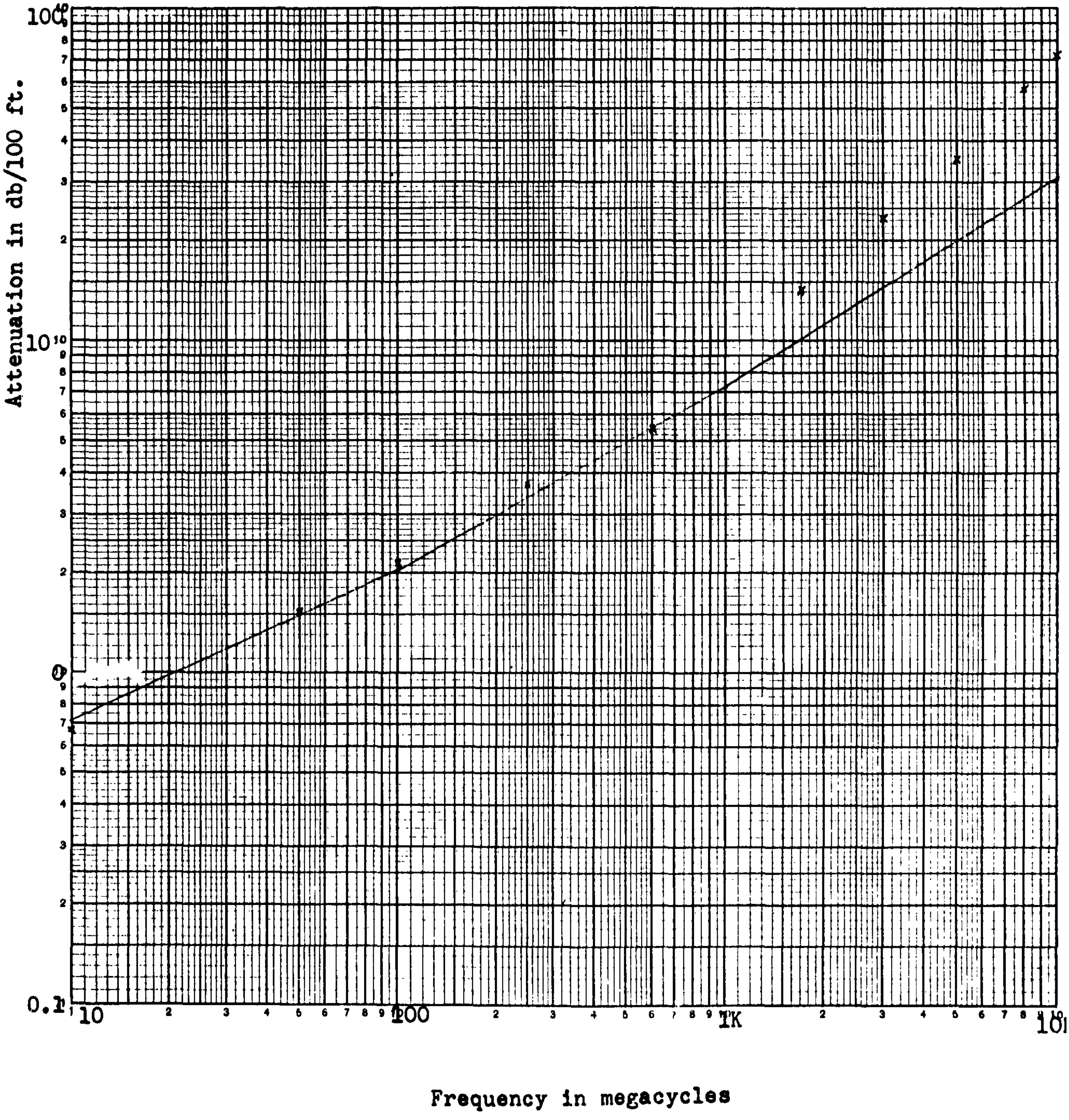
Graph 1.3 - Computed and measured attenuation of sample 3



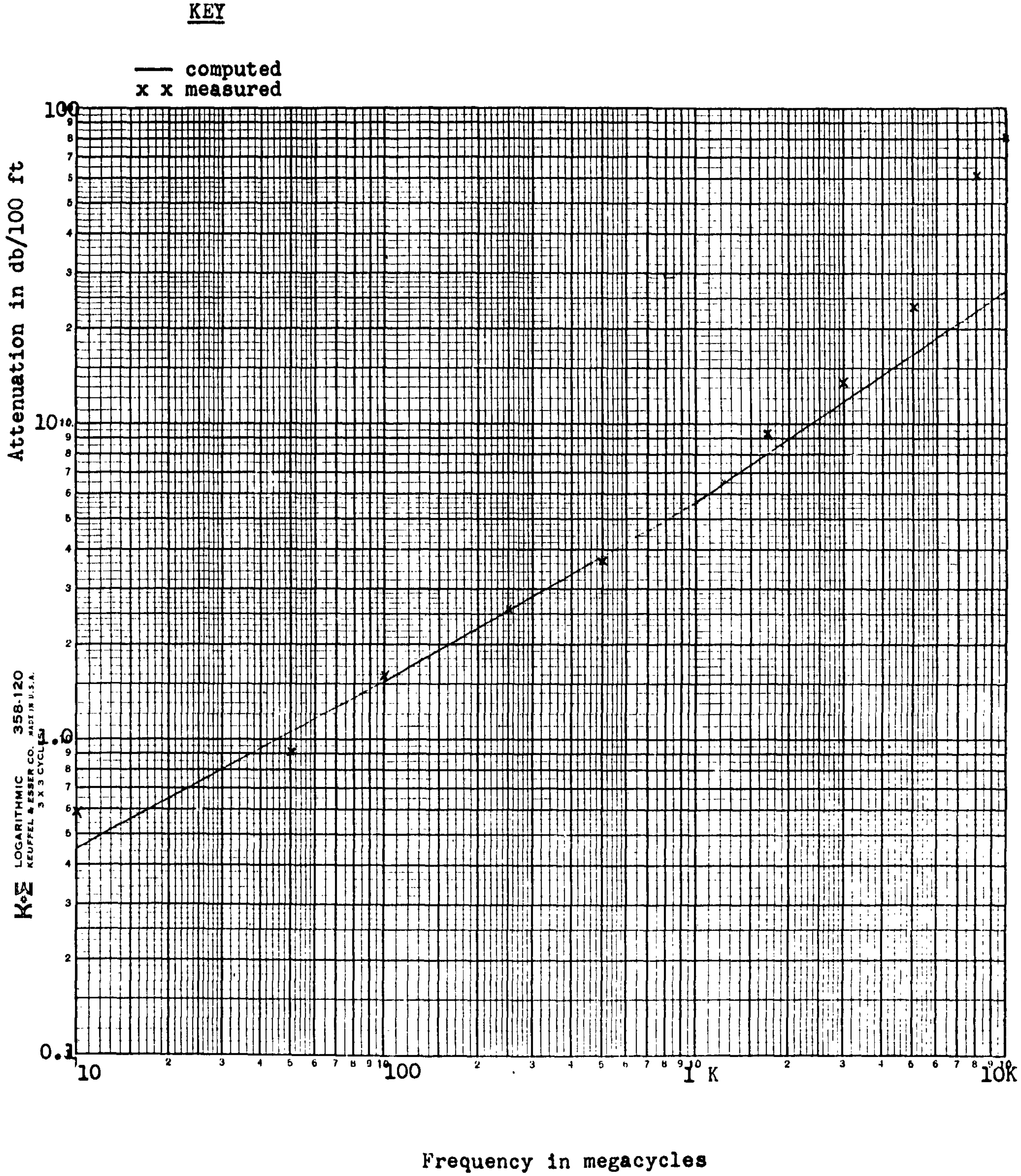
Graph 1.4 - Computed and measured attenuation of sample 4

KEY

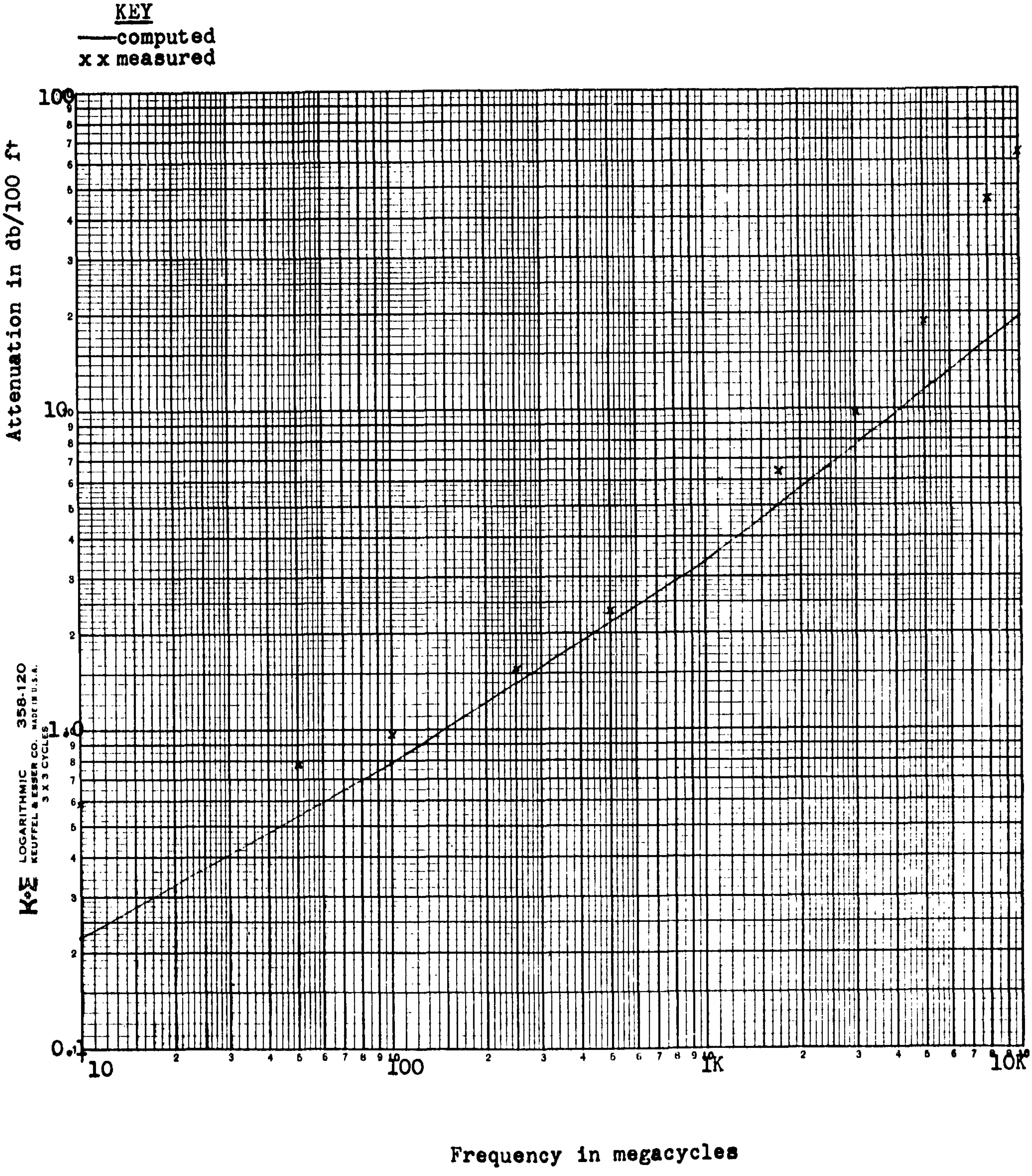
—— computed
x x measured



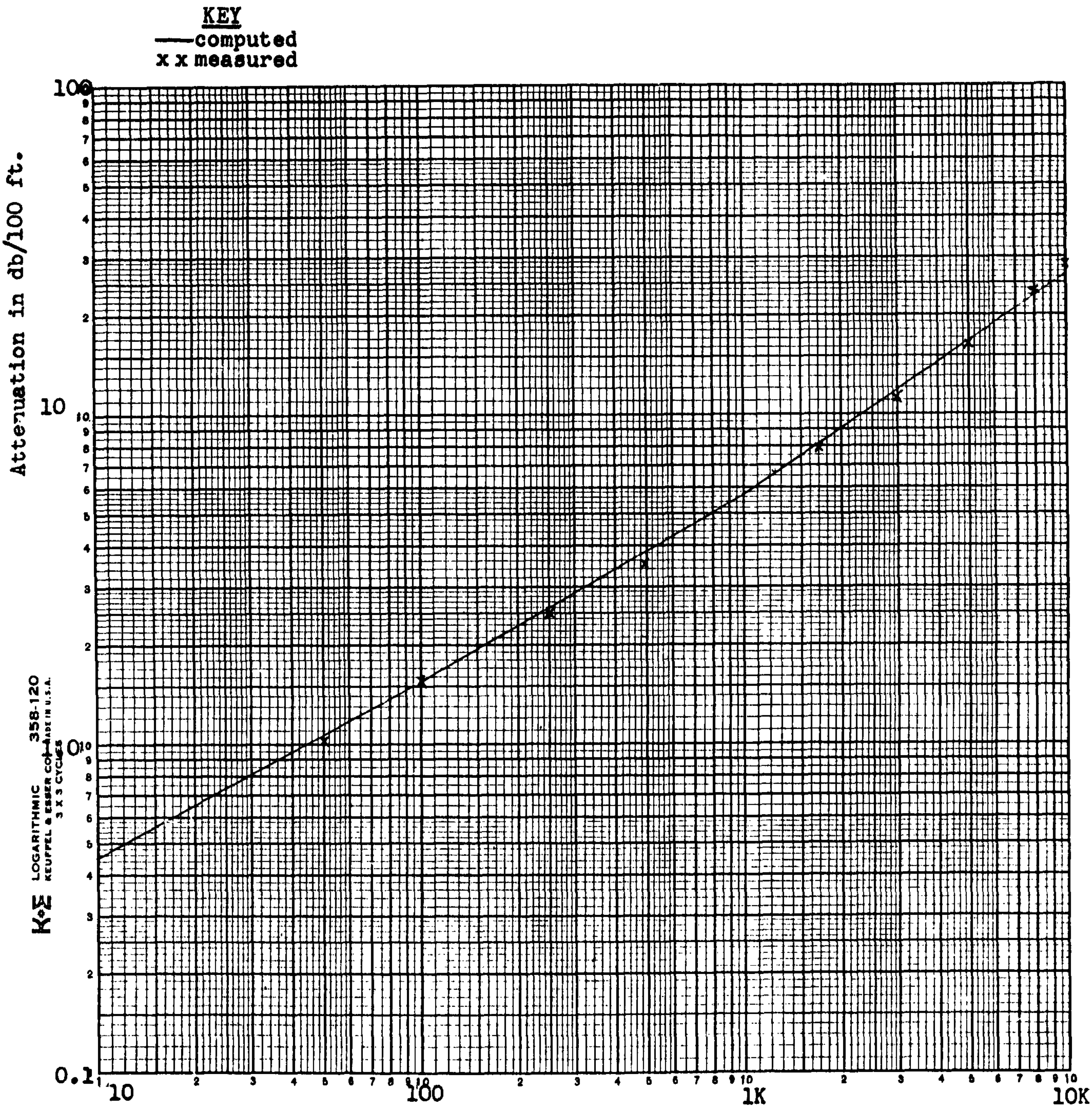
Graph 1.5 - Computed and measured attenuation of sample 5



Graph 1.6 - Computed and measured attenuation of sample 6

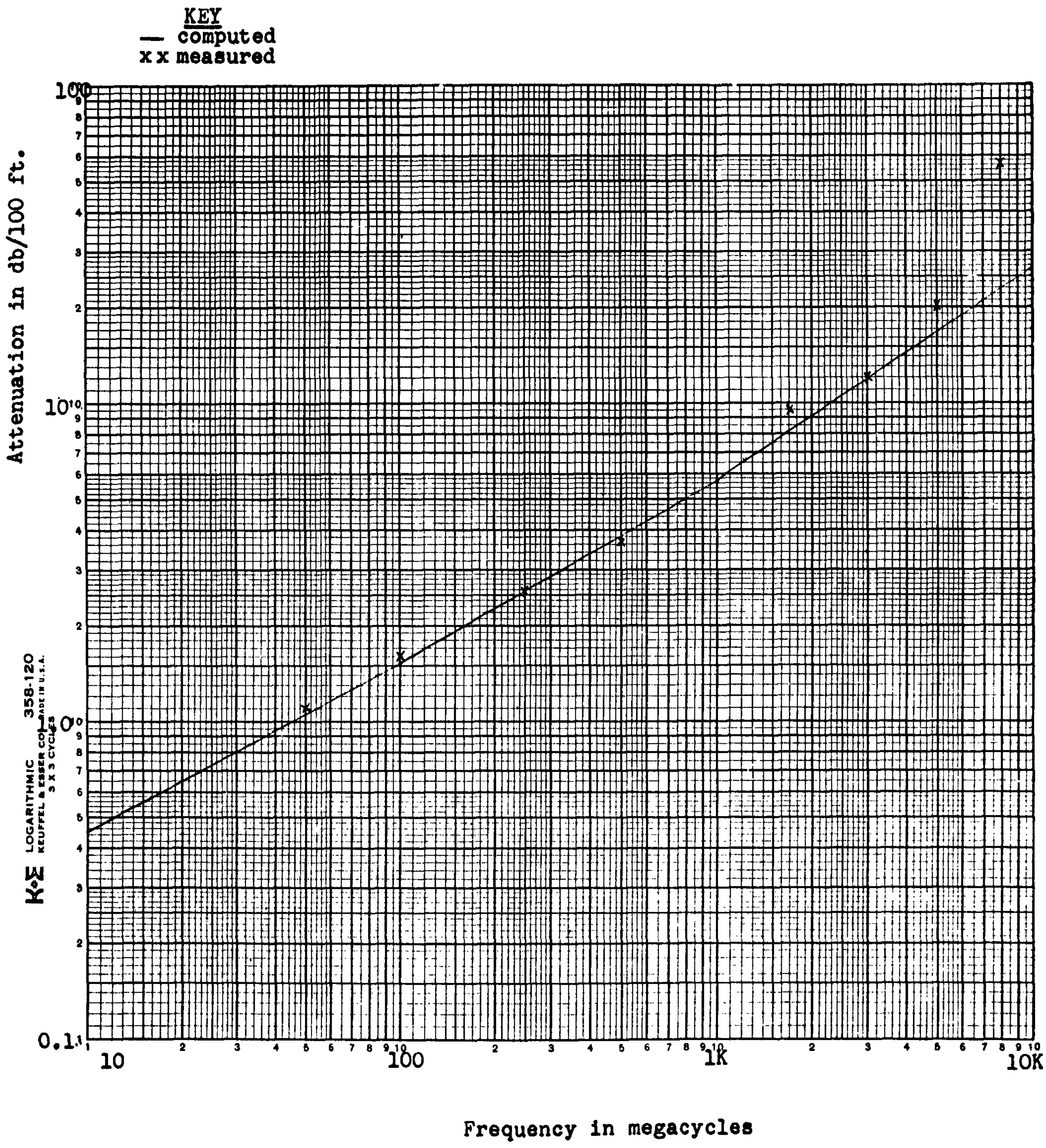


Graph 1.7 - Computed and measured attenuation of sample 7



Frequency in megacycles

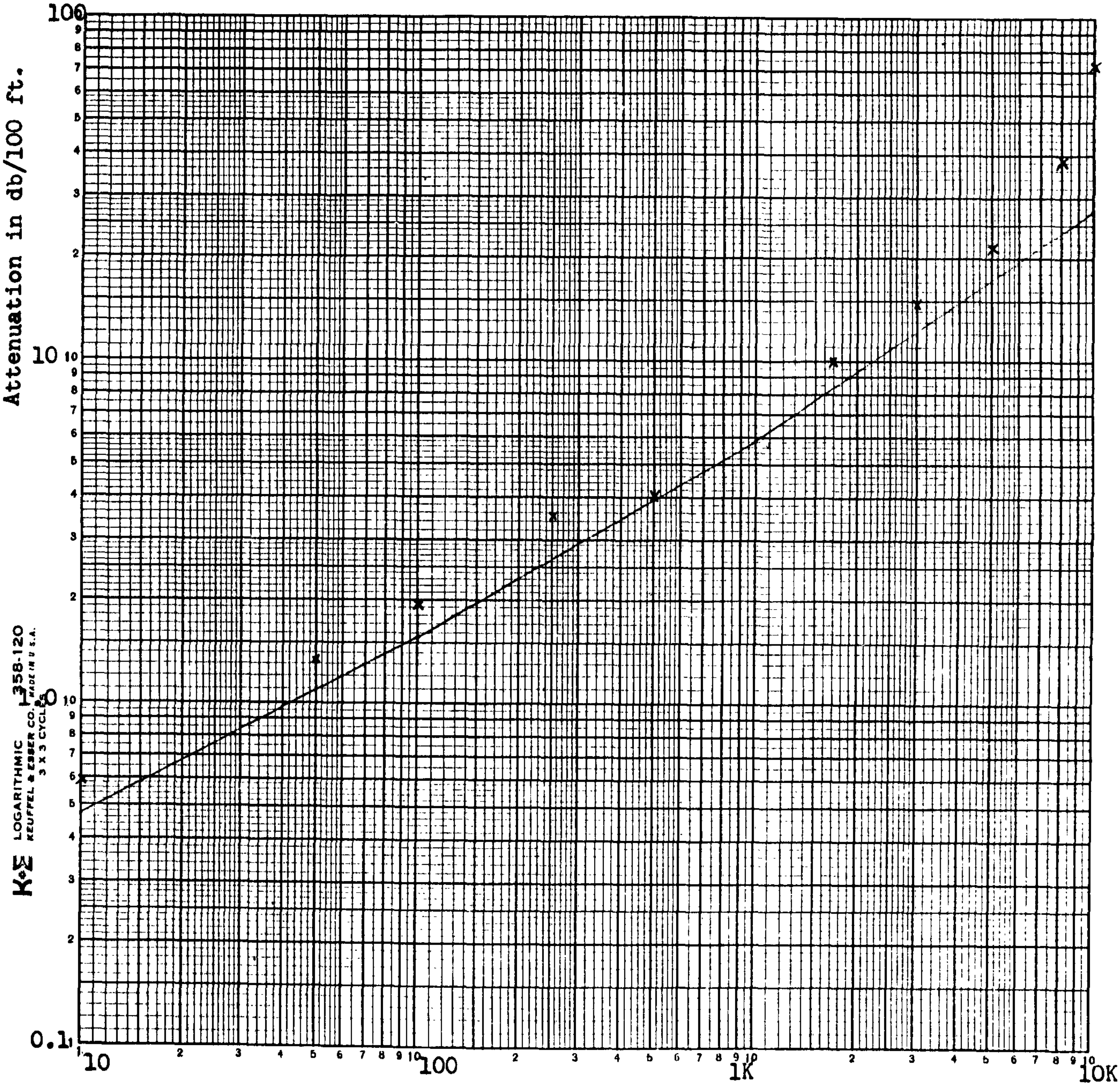
Graph 1.8 - Computed and measured attenuation of sample. 8



Graph 1.9 - Computed and measured attenuation of sample 10

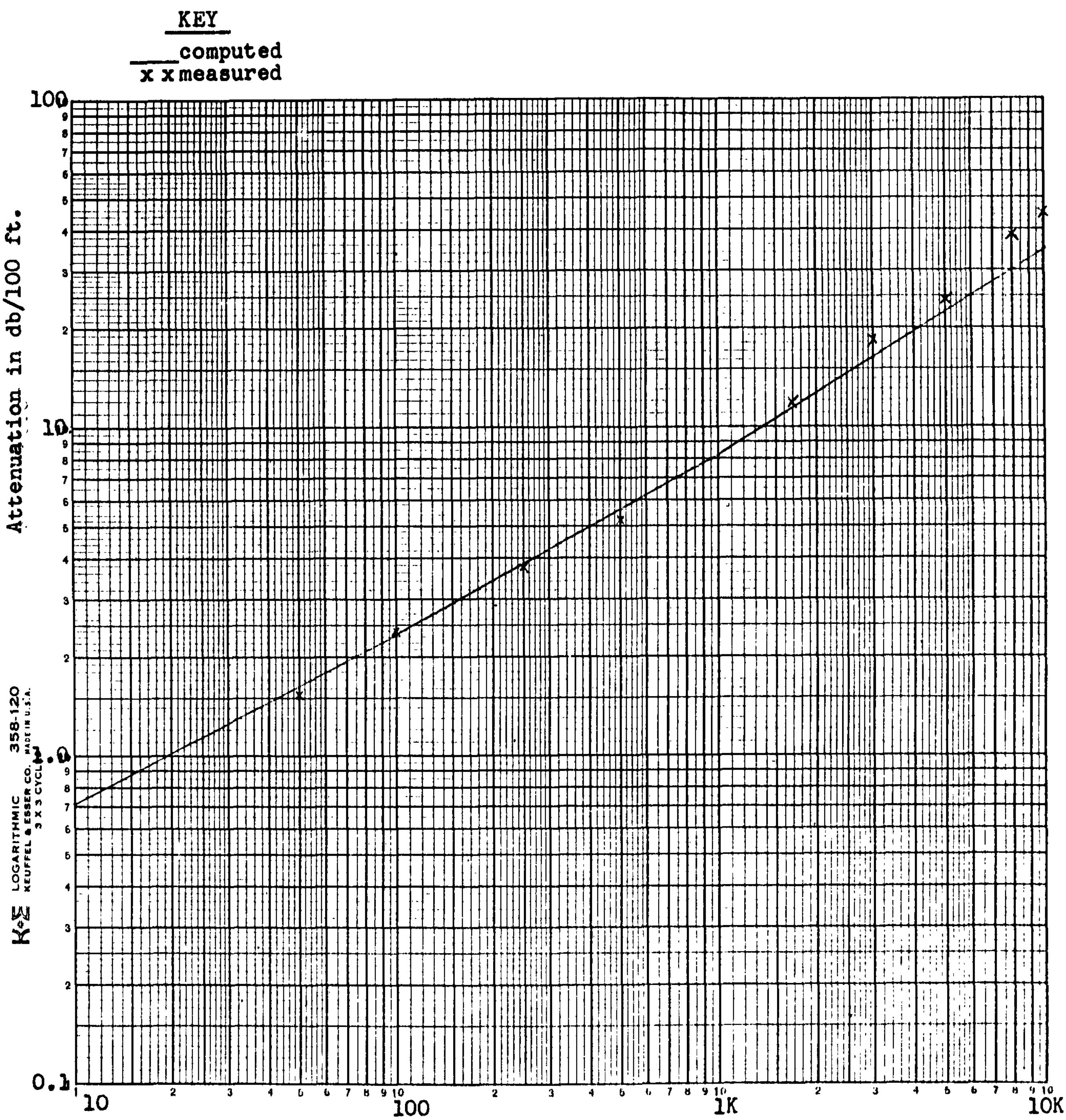
KEY

——computed
x x measured



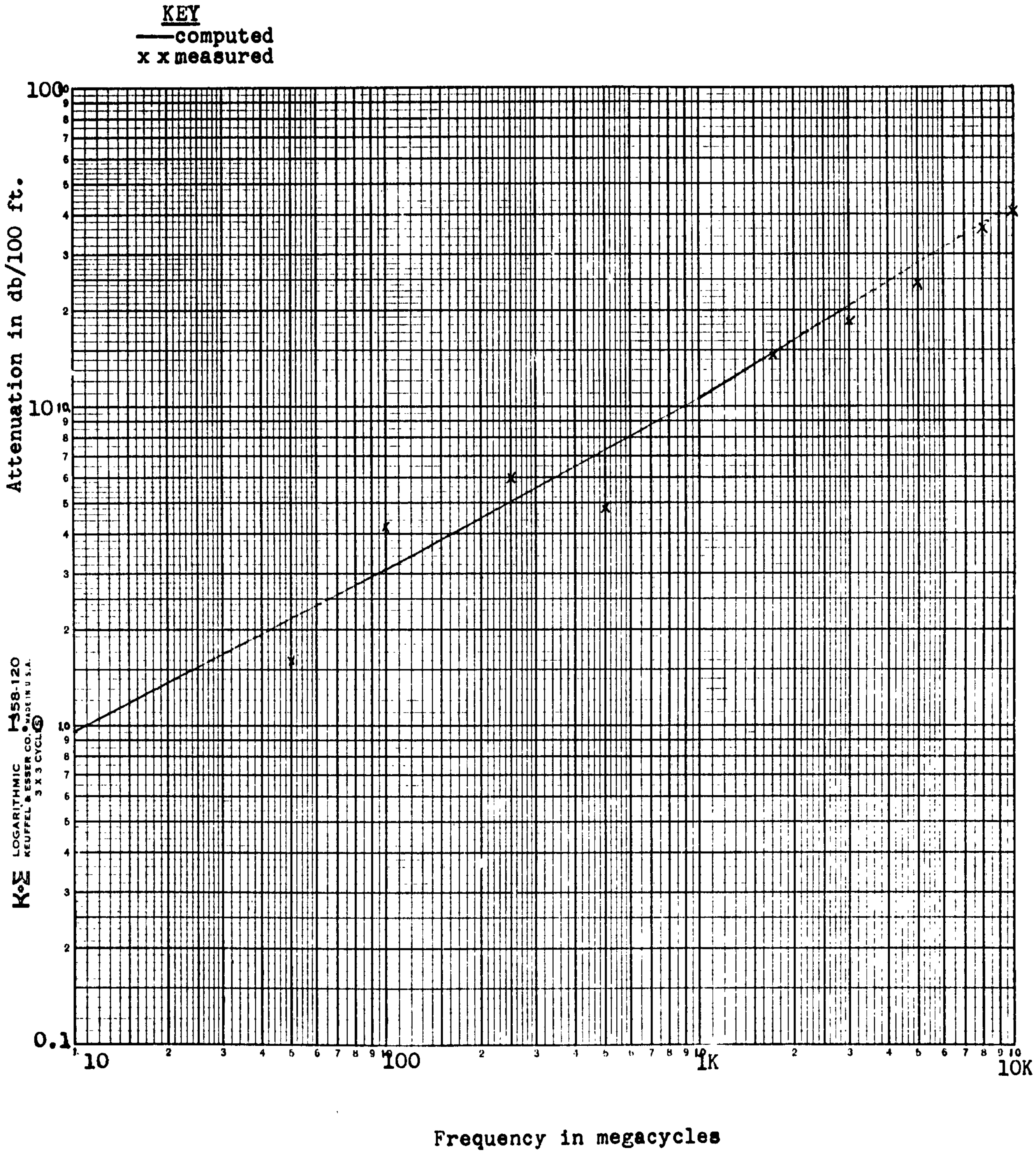
Frequency in megacycles

Graph 1.10 - Computed and measured attenuation of sample 11

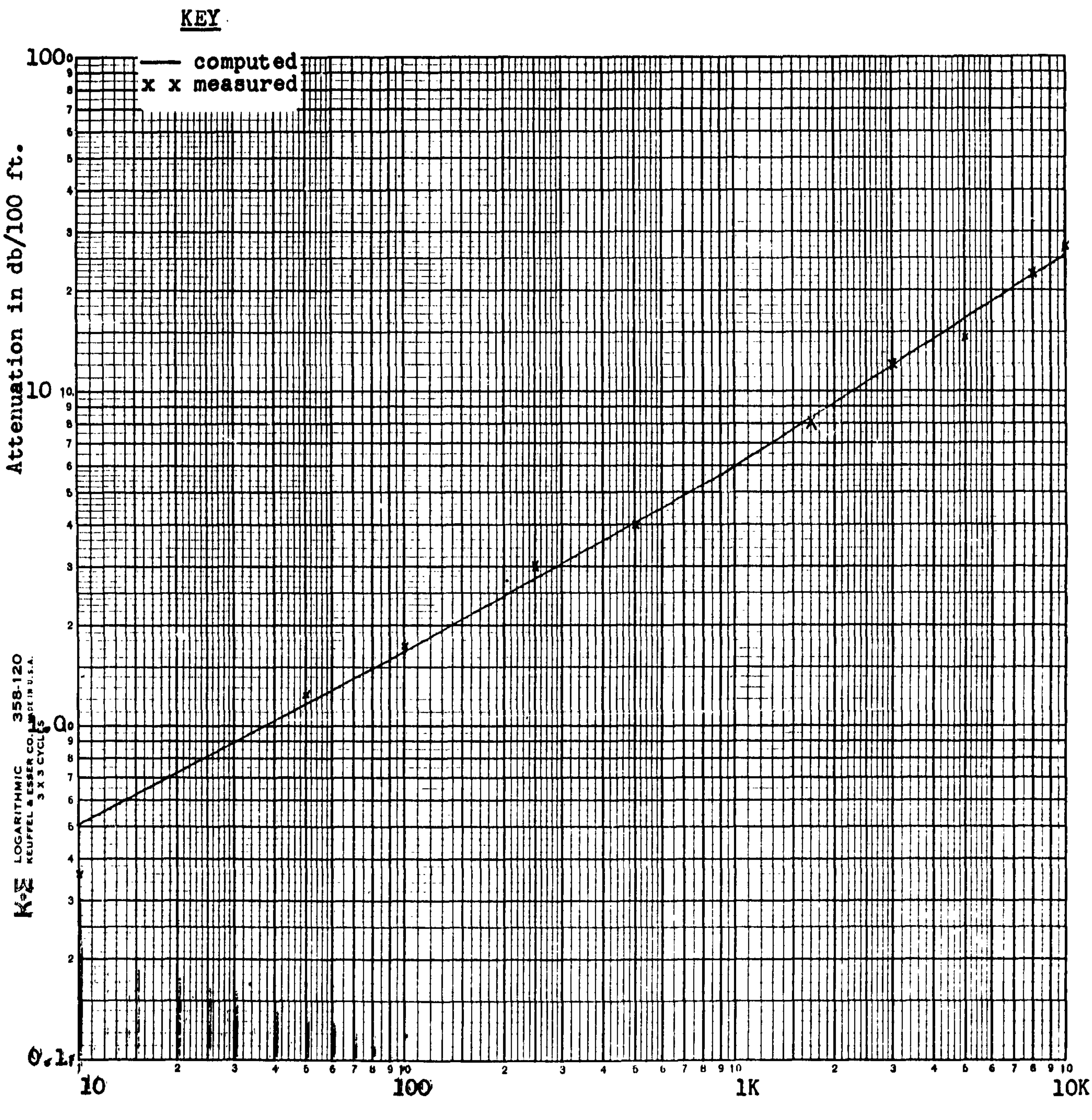


Frequency in megacycles

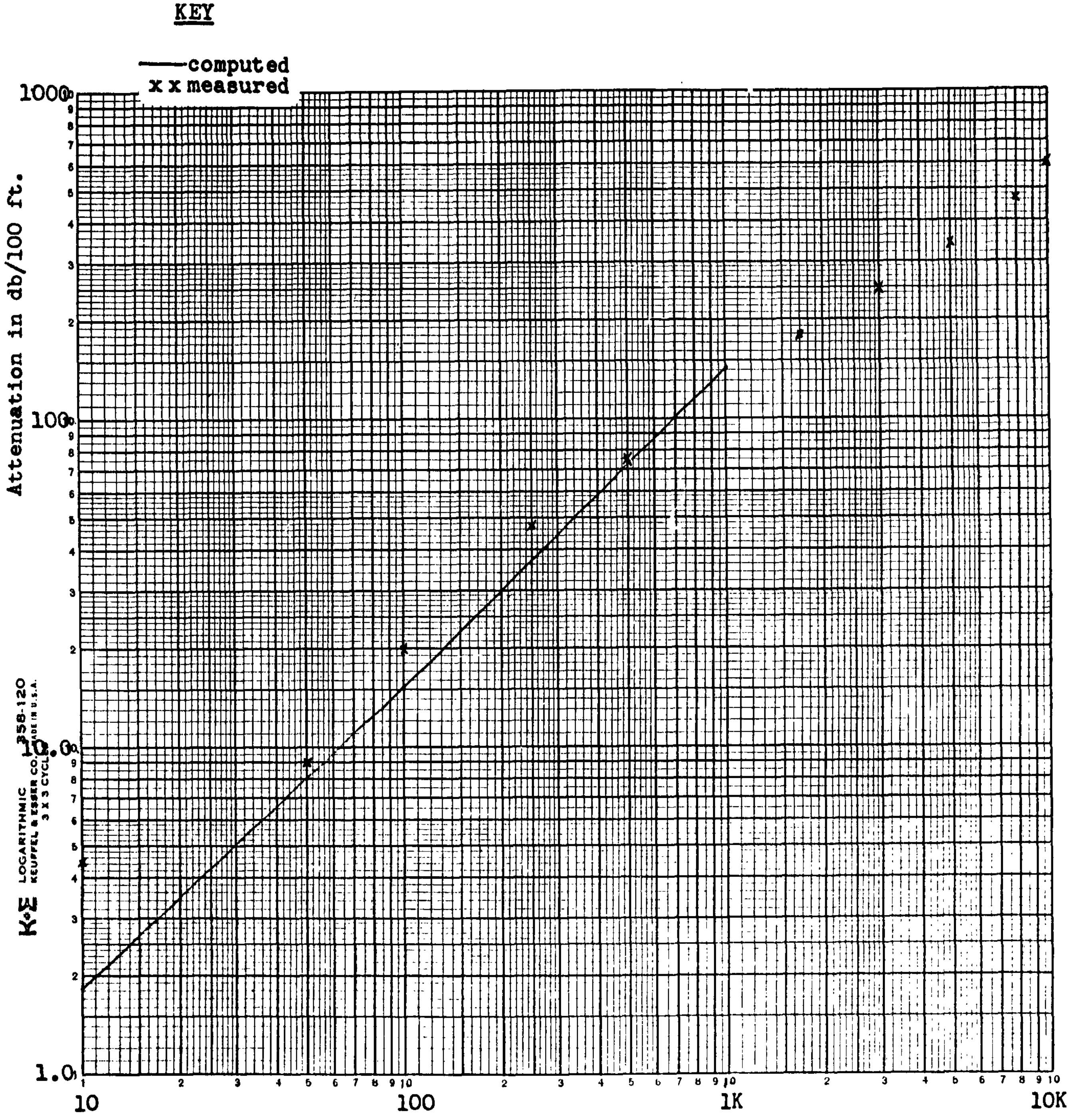
Graph 1.11 - Computed and measured attenuation of sample 12



Graph 1.12 - Computed and measured attenuation of sample 13

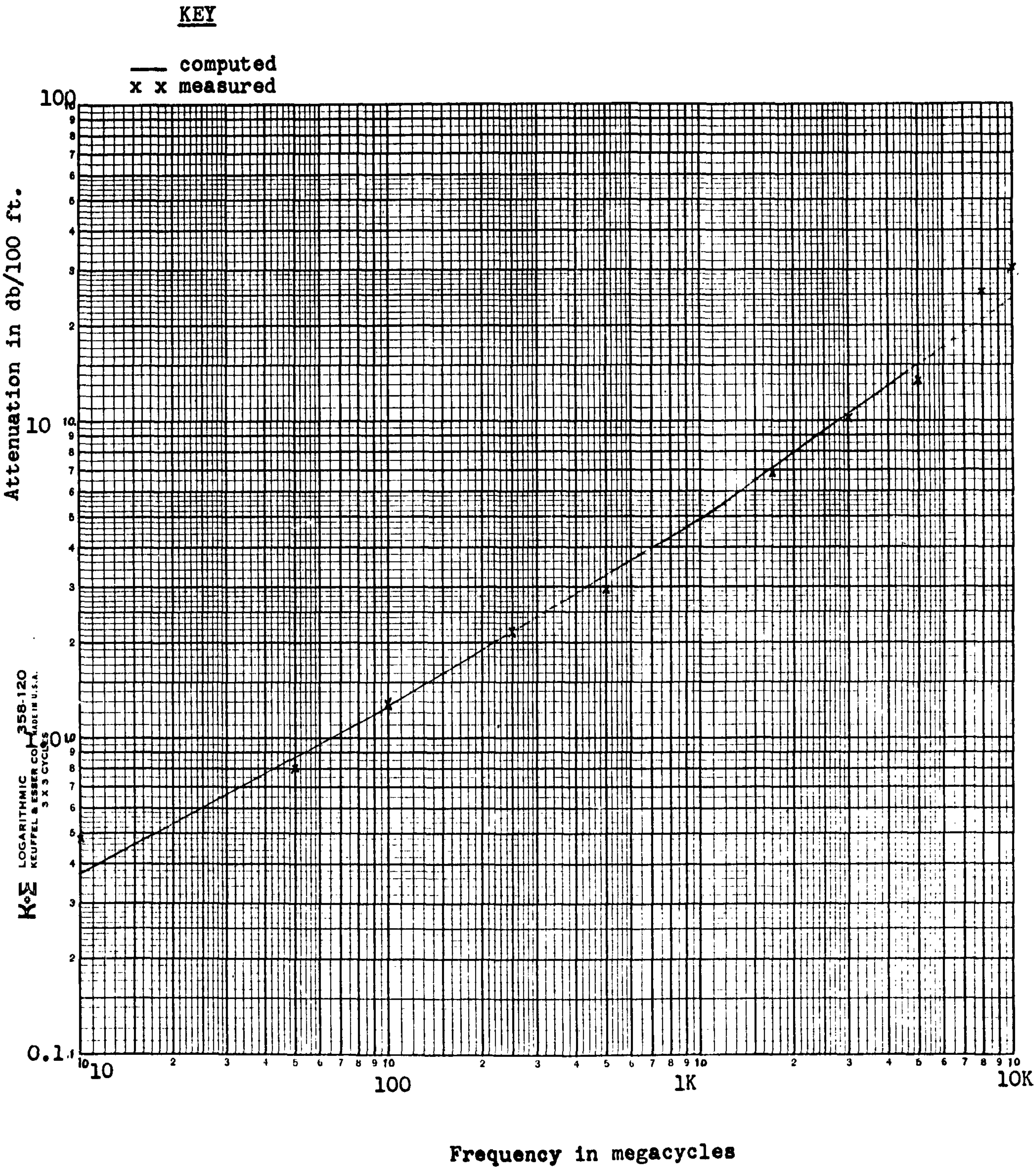


Graph 1.13 - Computed and measured attenuation of sample 15



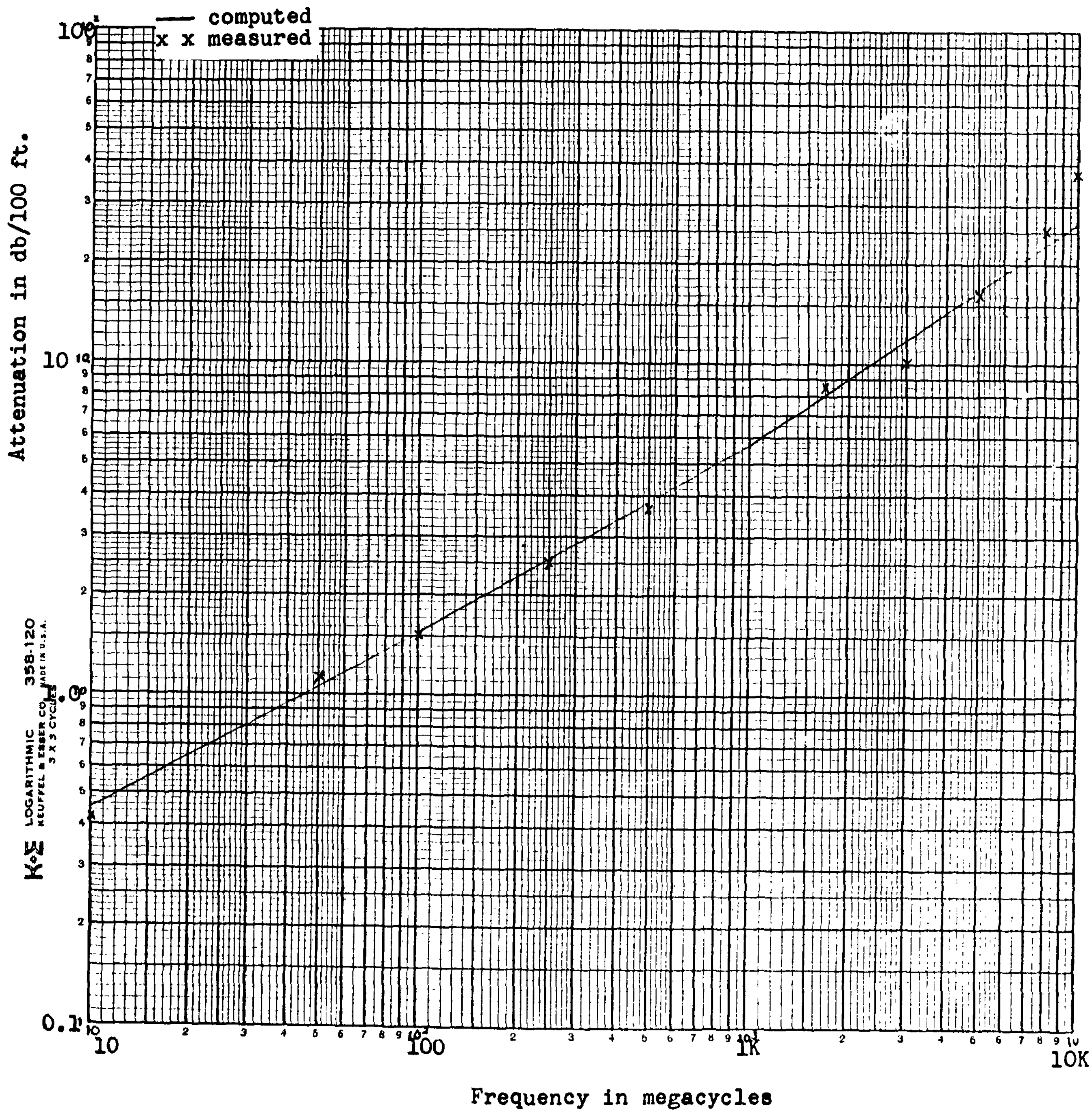
Frequency in megacycles

Graph 1.14 - Computed and measured attenuation of sample 17



Graph 1.15 - Computed and measured attenuation of sample 18

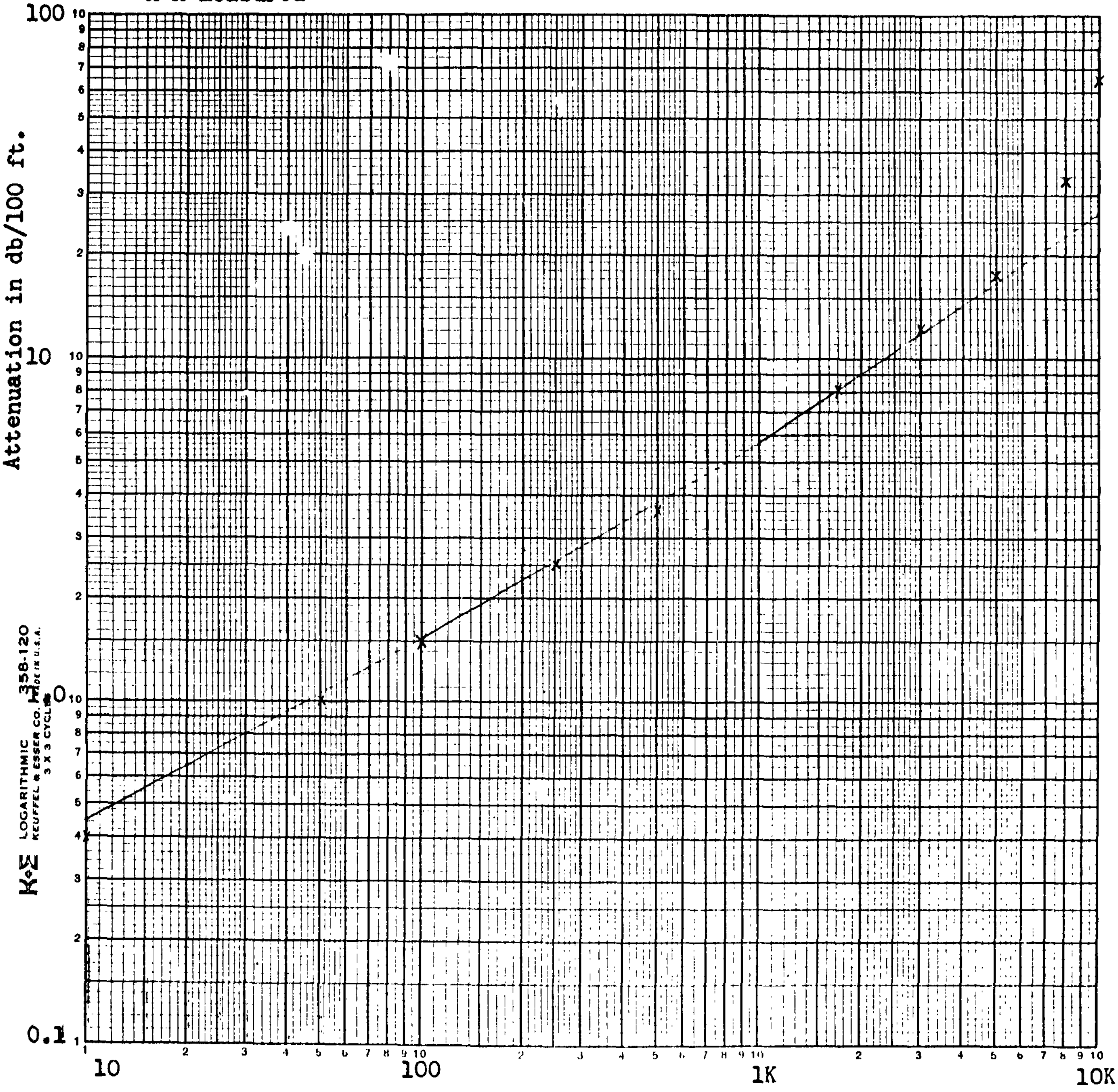
KEY



Graph 1.16 - Computed and measured attenuation of sample 20

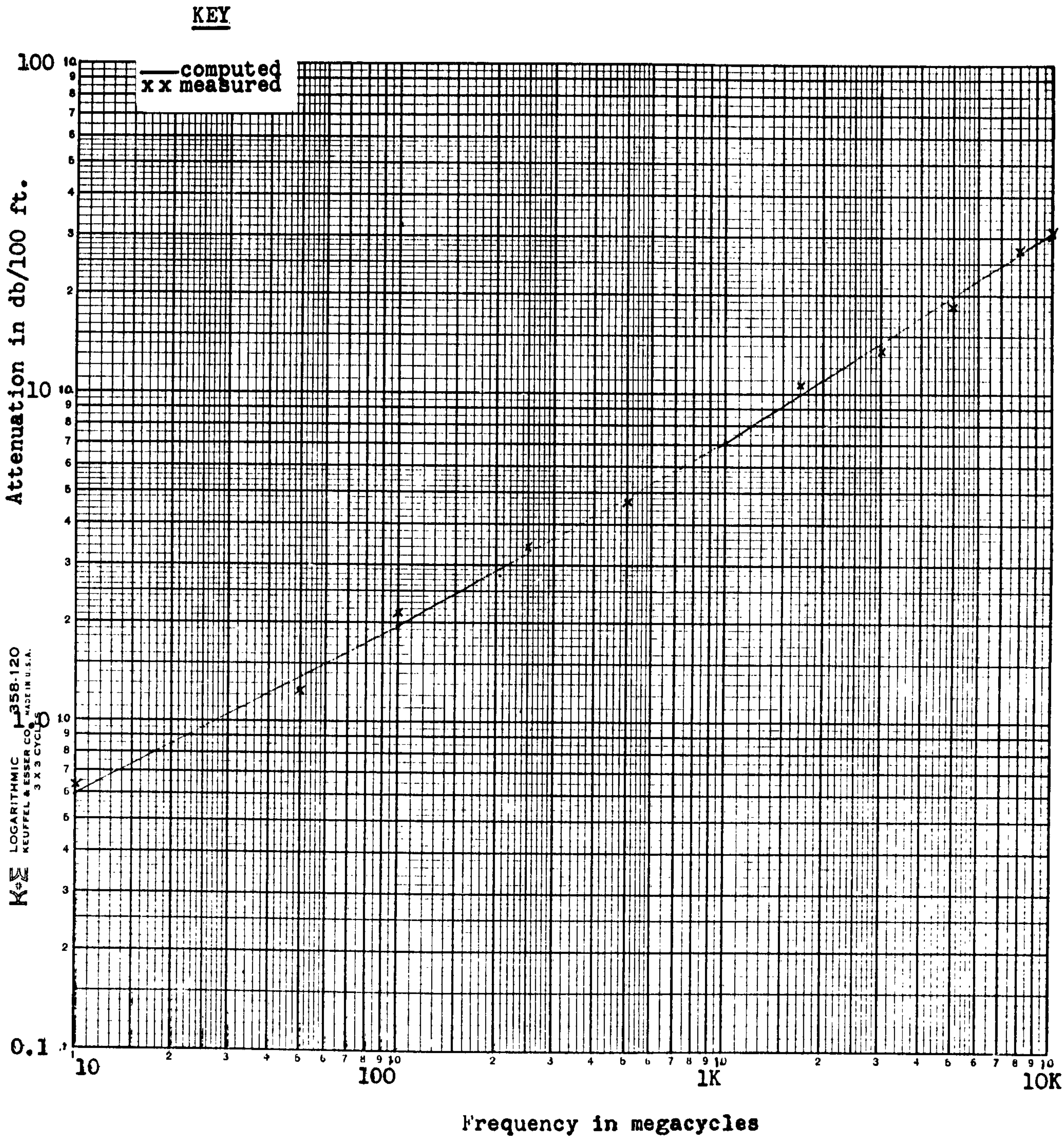
KEY

—— computed
x x measured

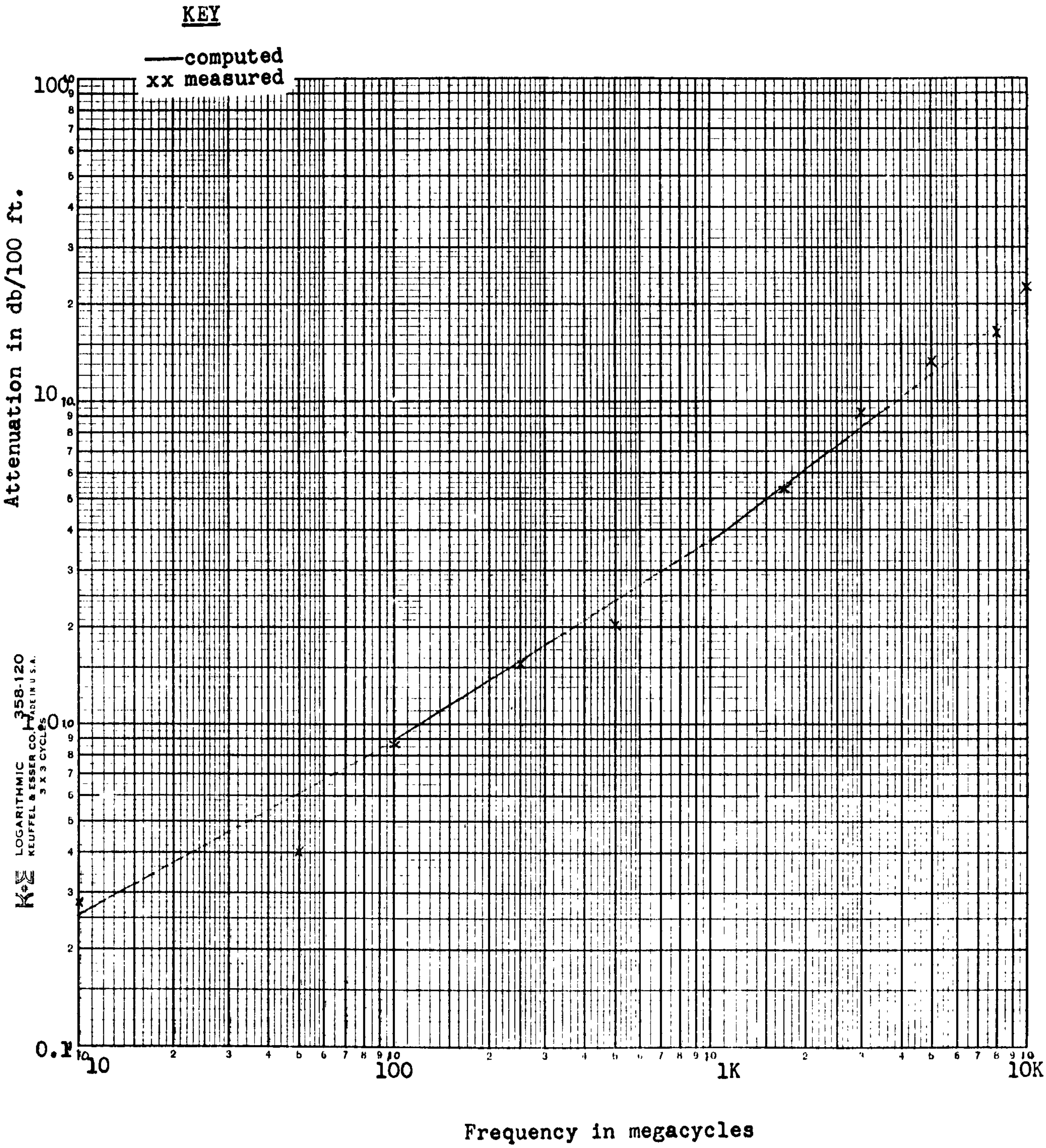


Frequency in megacycles

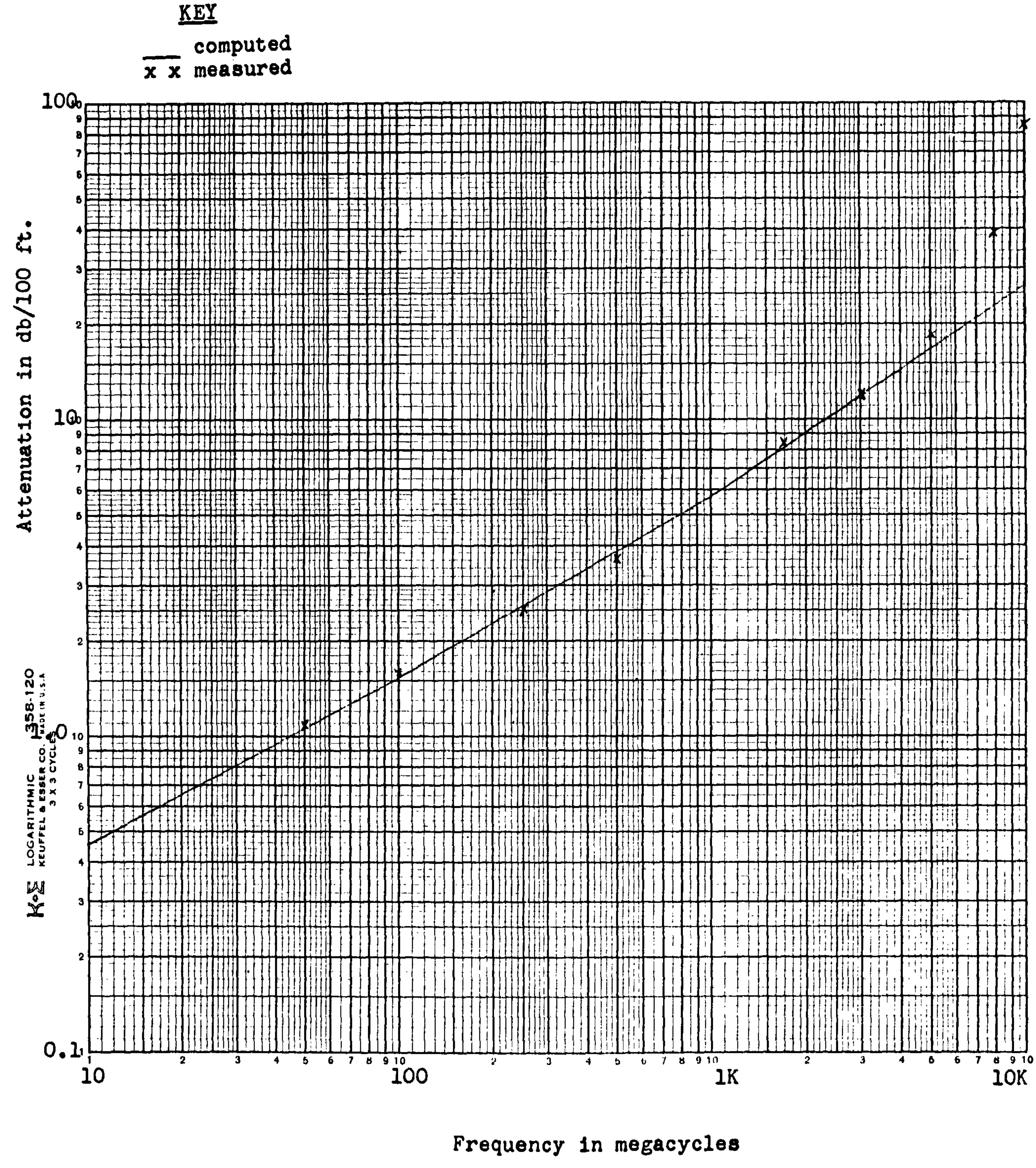
Graph 1.17 - Computed and measured attenuation of sample 21



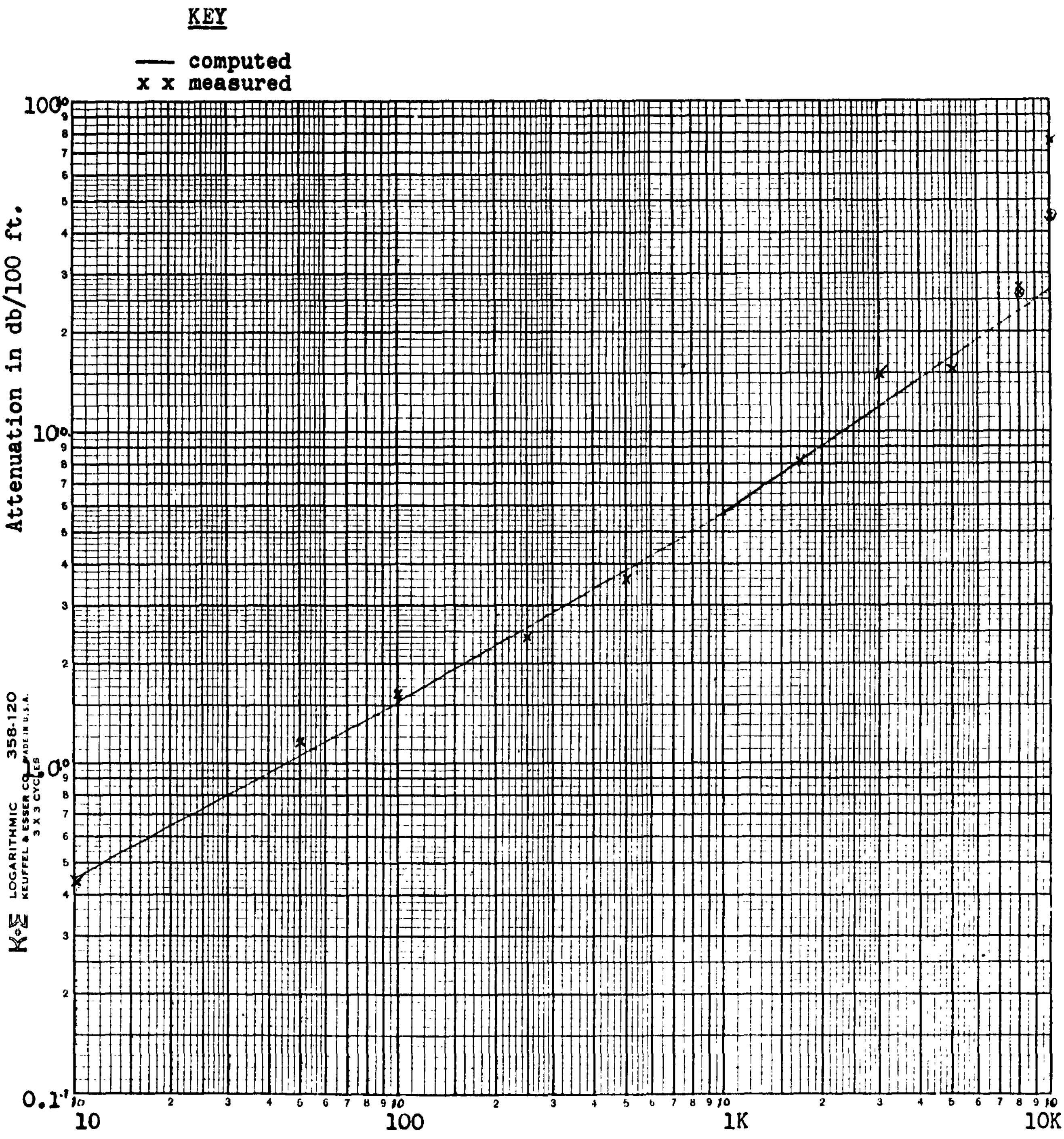
Graph 1.18 - Computed and measured attenuation of sample 22



Graph 1.19 - Computed and measured attenuation of sample 23

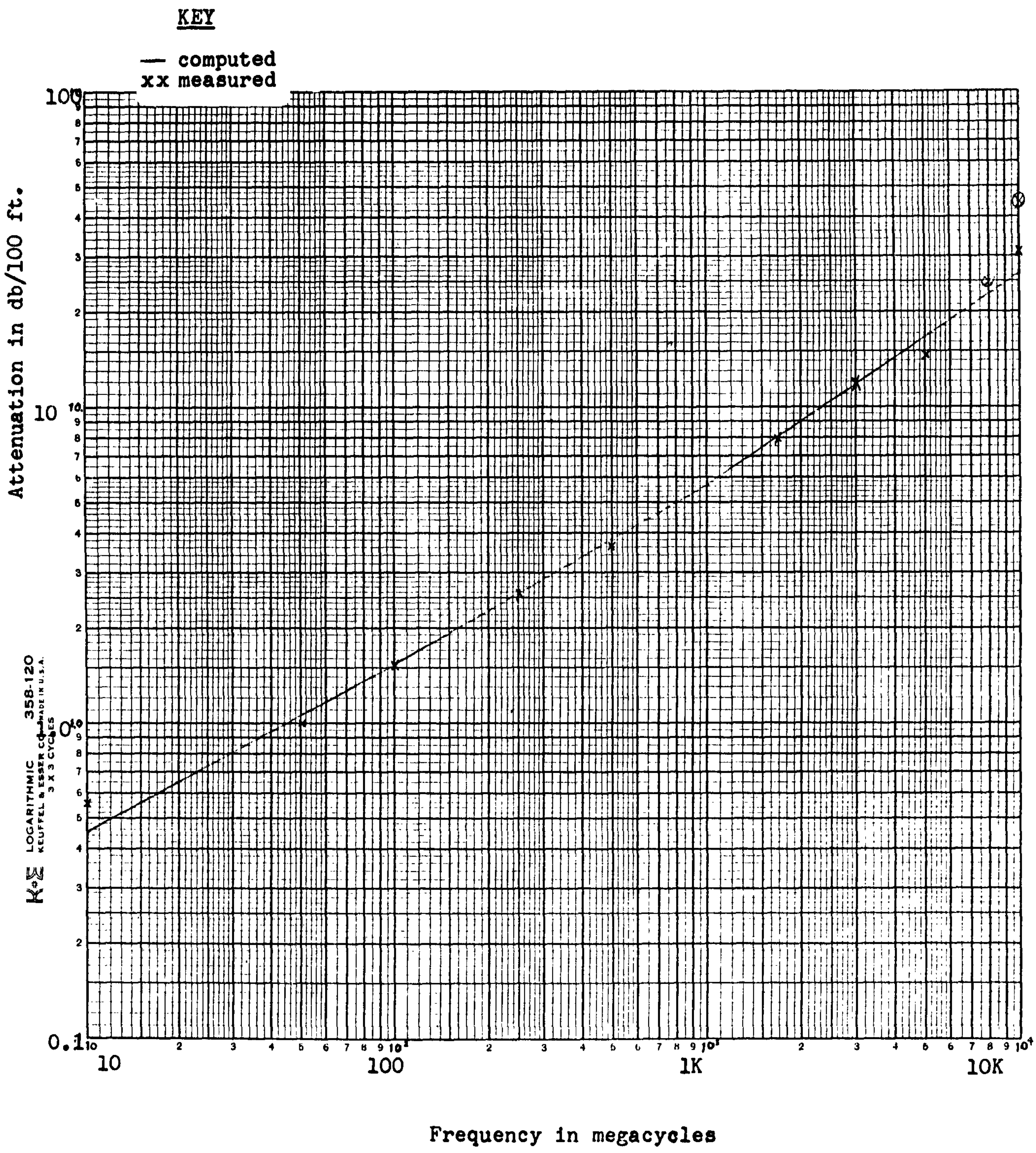


Graph 1.20 - Computed and measured attenuation of sample 24

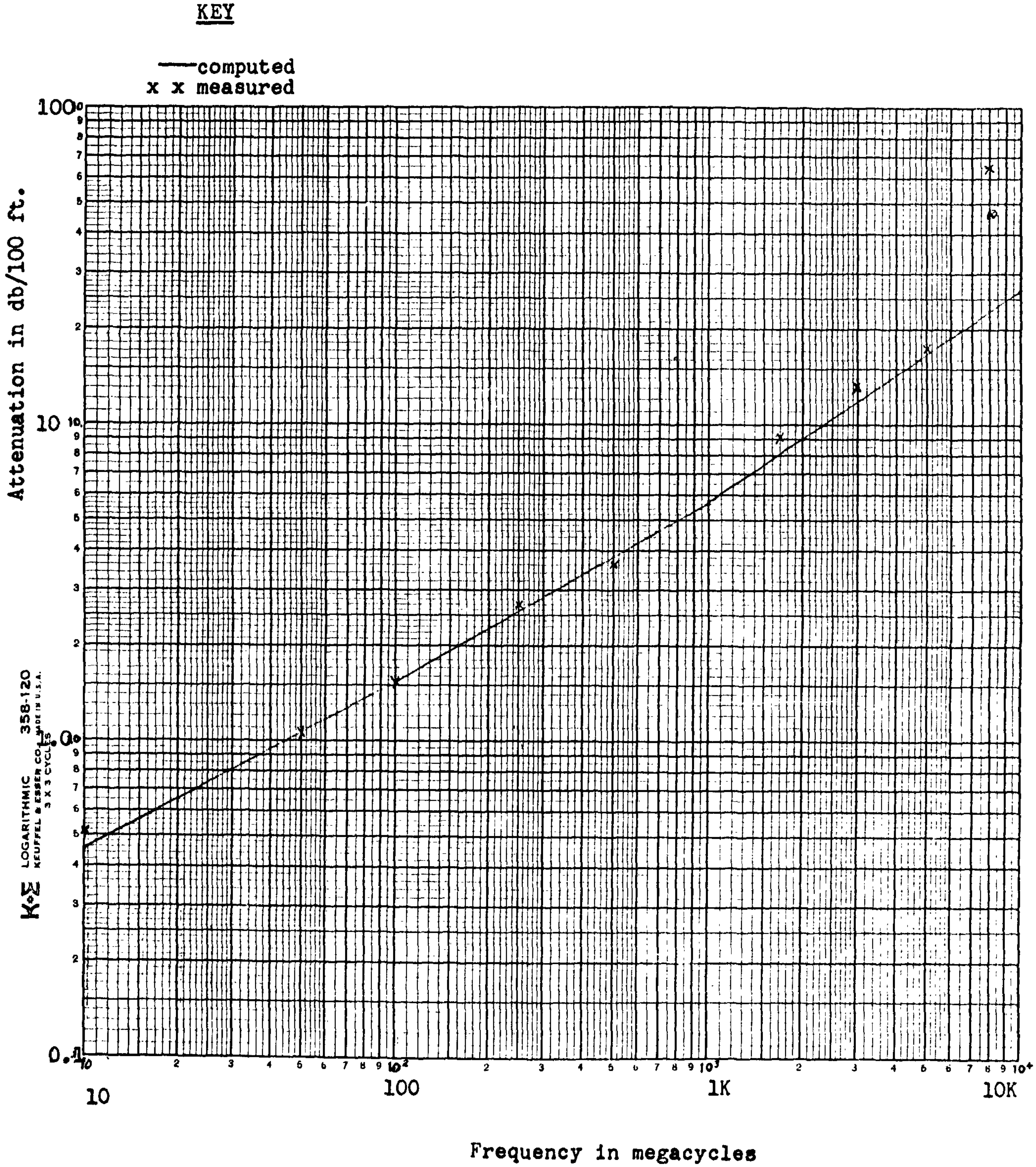


Frequency in megacycles

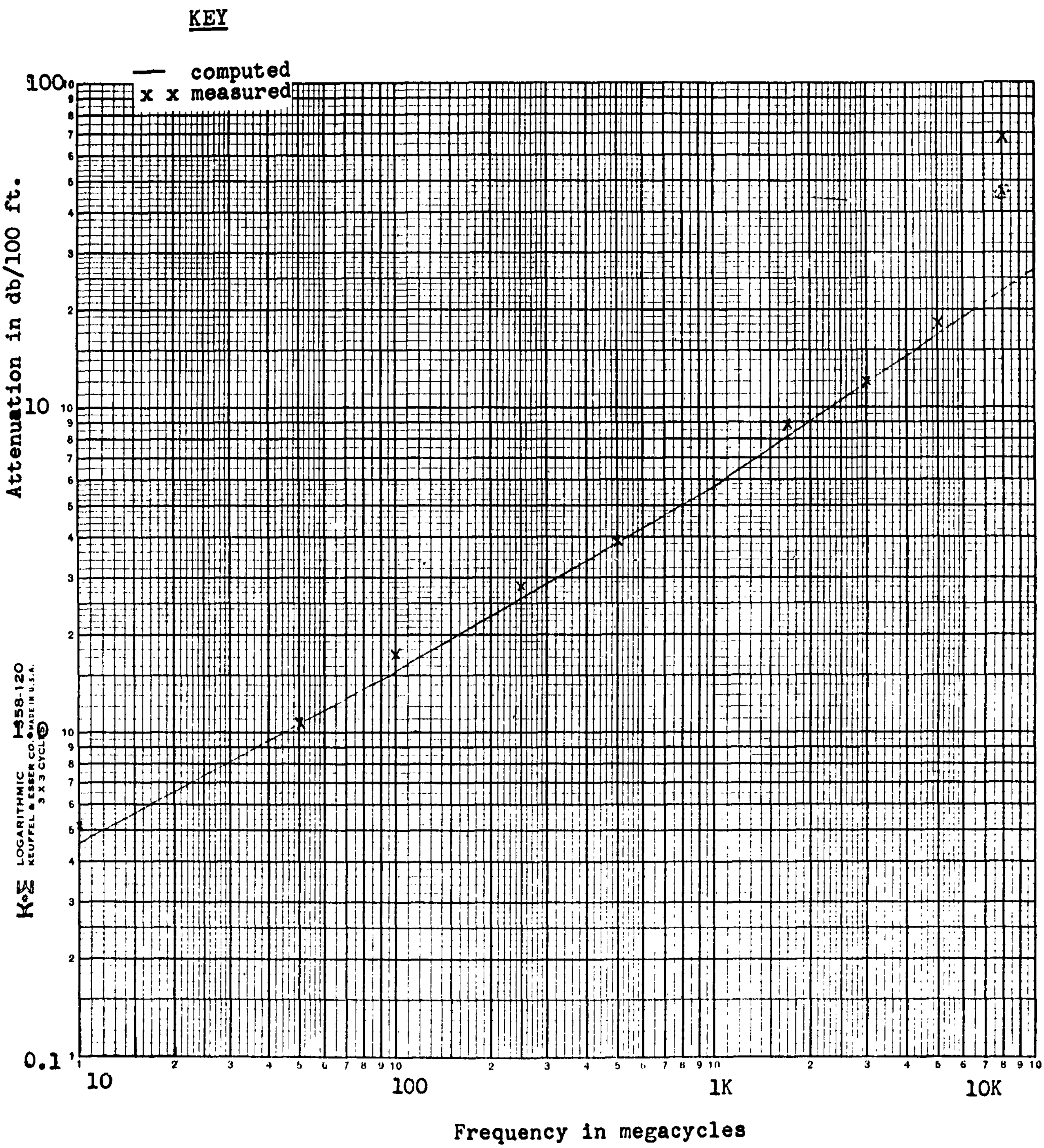
Graph 1.21 - Computed and measured attenuation of sample 25



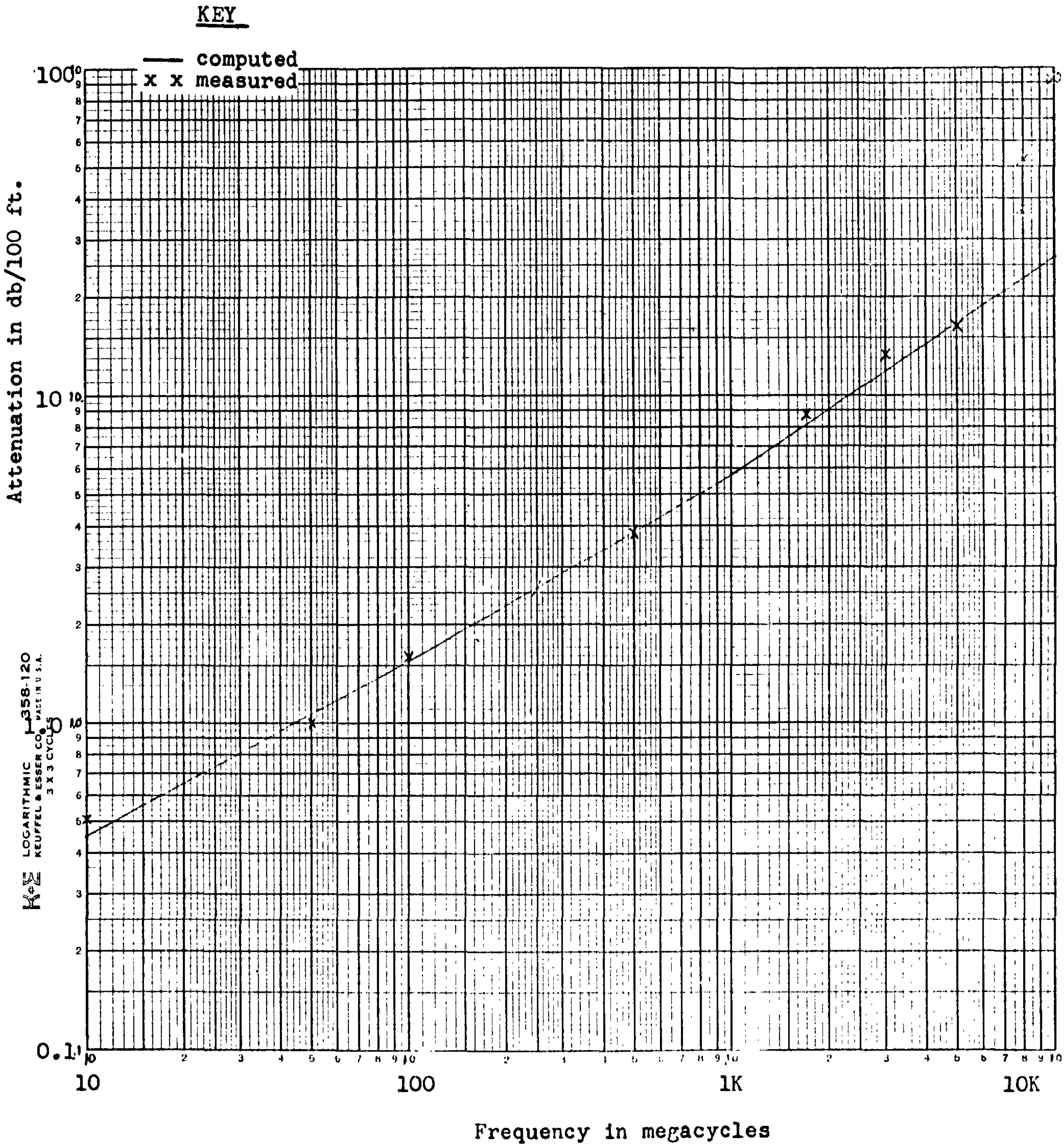
Graph 1.22 - Computed and measured attenuation of sample 26



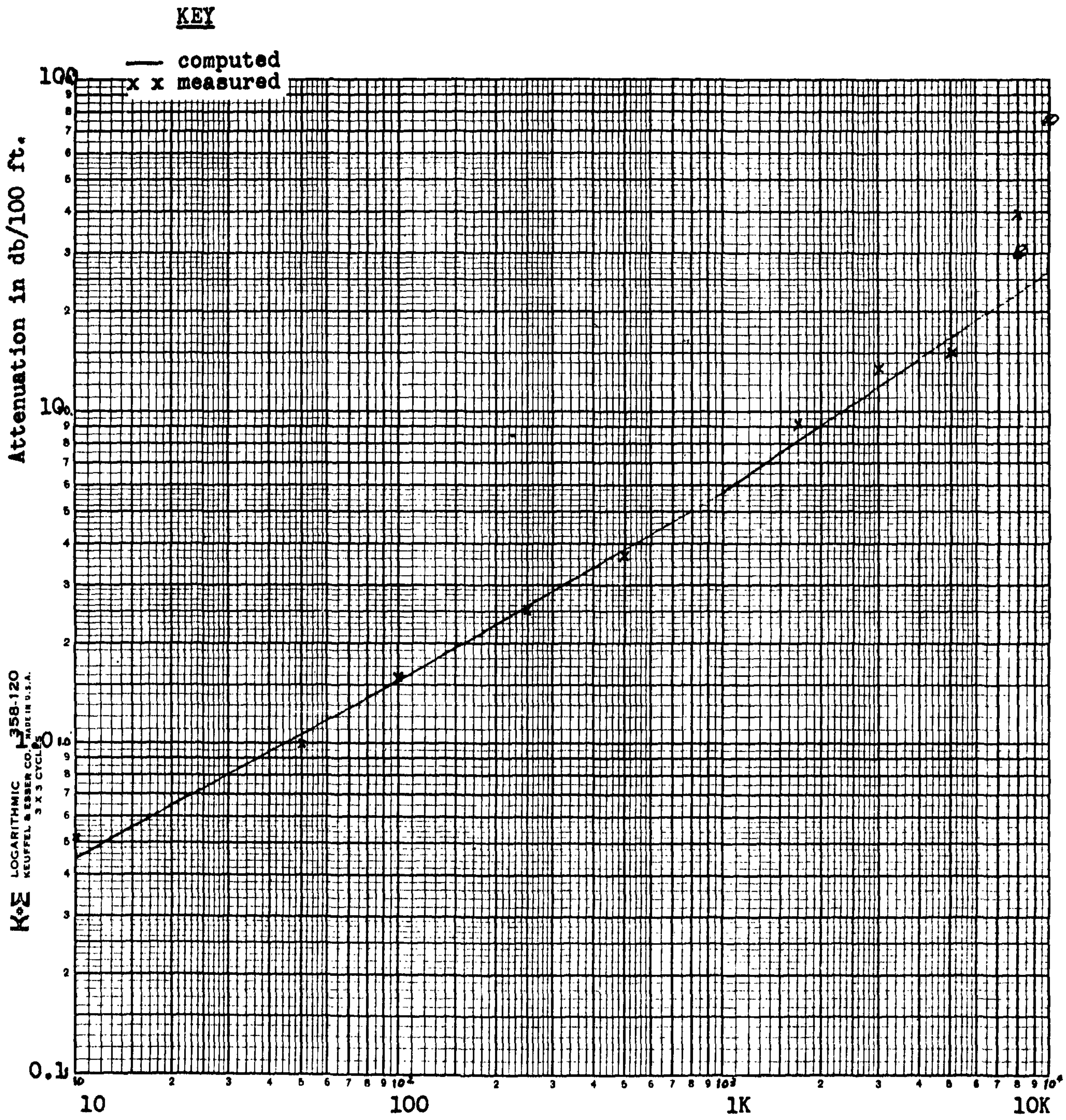
Graph 1.23 - Computed and measured attenuation of sample 27



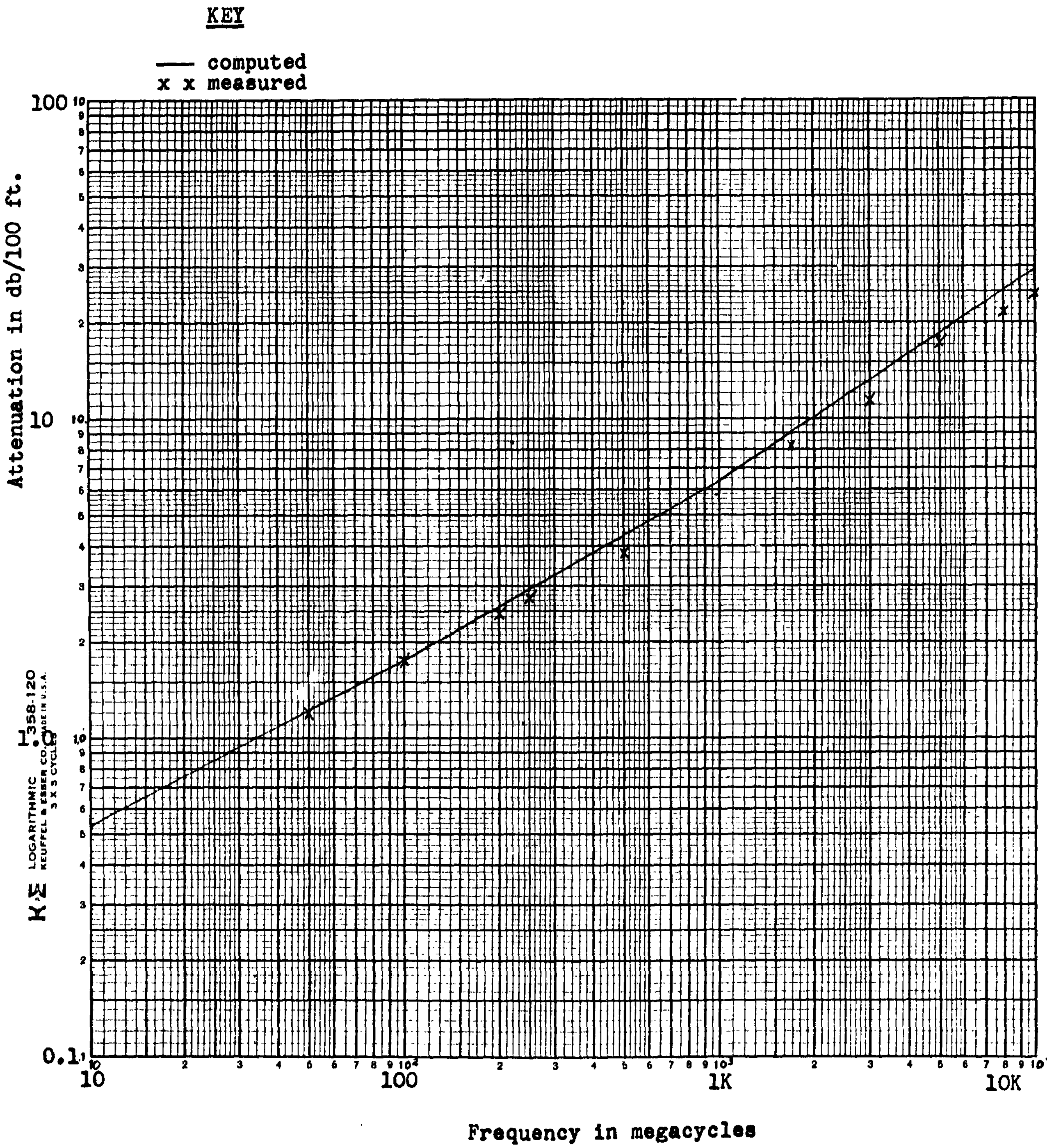
Graph 1.24 - Computed and measured attenuation of sample 28



Graph 1.25- Computed and measured attenuation of sample 29



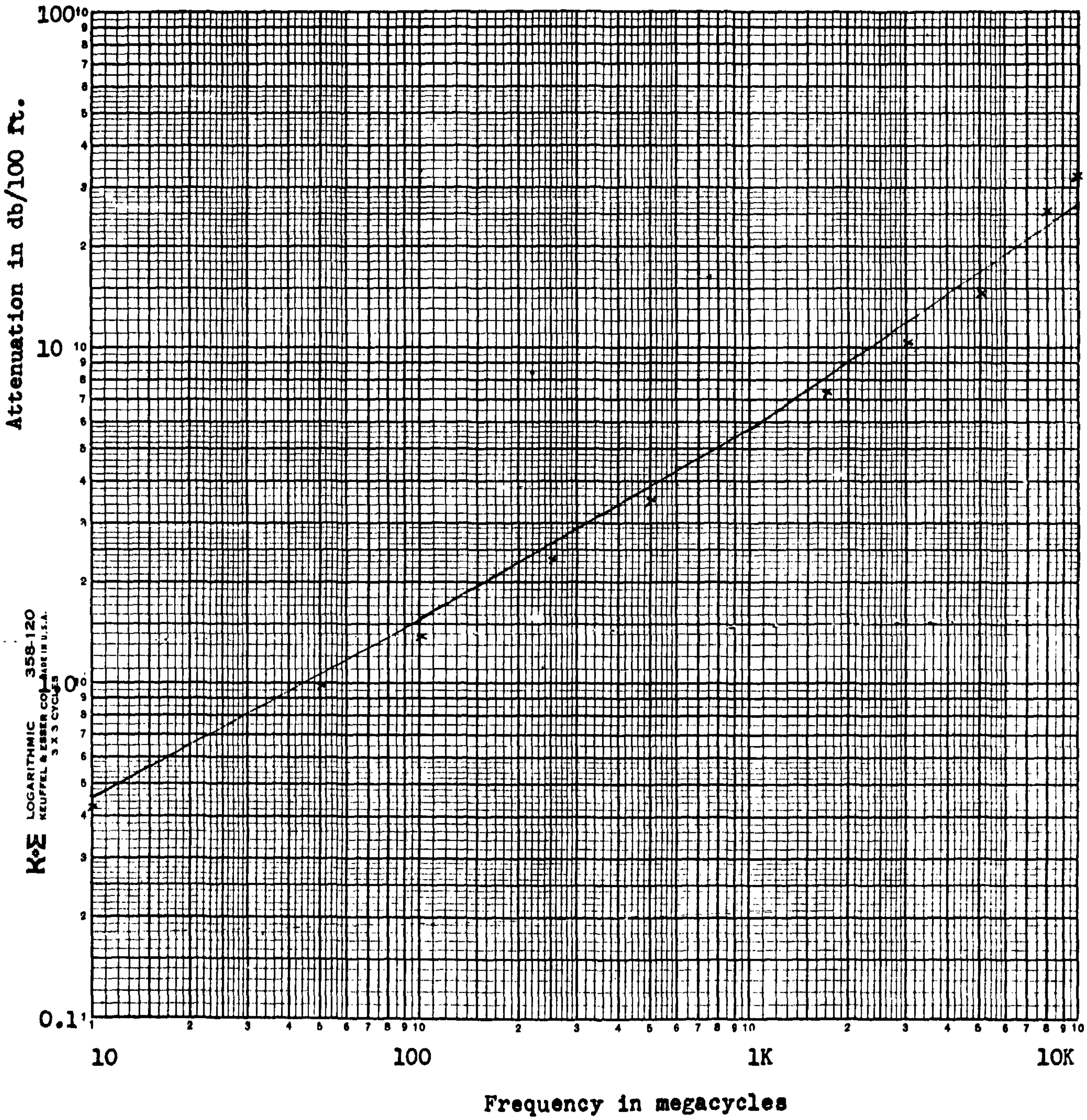
Graph 1.26 - Computed and measured attenuation of sample 30



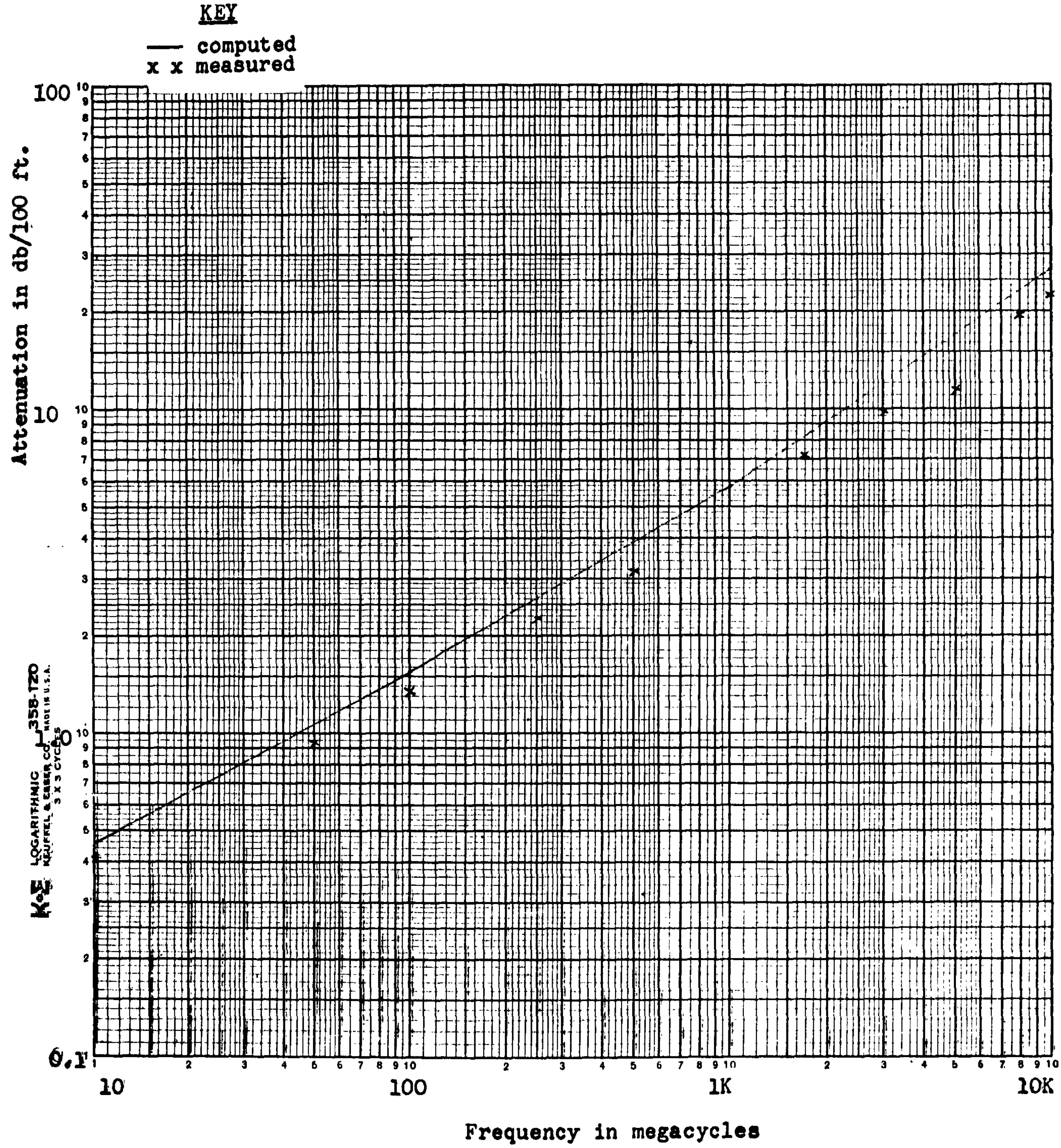
Graph 1.27 - Computed and measured attenuation of sample 31

KEY

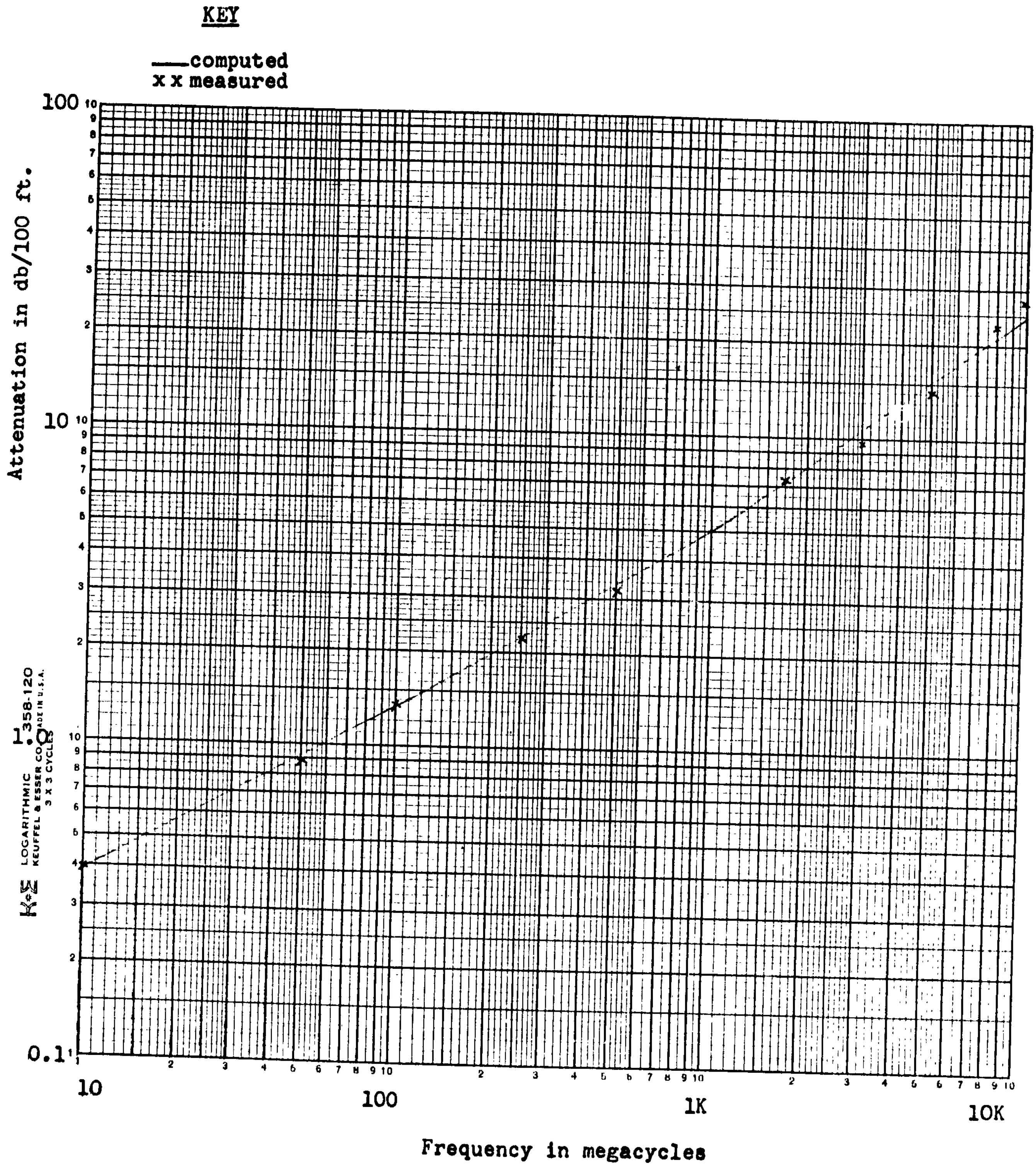
— computed
xx measured



Graph 1.28 - Computed and measured attenuation of sample 32



Graph 1.29 - Computed and measured attenuation of sample 33



1.3.4 Discussion of attenuation test results - Graphs 1.1 through 1.29 show the measured attenuation of the samples is quite accurately predicted by the expressions given in paragraph 1.3.3 on page 8. Graphs 1.27, 1.28 and 1.29 indicate the braid factor does not completely describe the attenuation characteristics of the braid. All the graphs show a need for evaluation of the contribution of the braid to the attenuation at frequencies above 3 GC. The results show a silver plated braid yields a much lower high frequency attenuation than a bare copper braid. The following paragraphs discuss individual attenuation test results in more detail.

1.3.4.1 Discussion of attenuation test results on samples 1, 21 and 30 - Graph 1.30, page 40, presents a comparison of the measured attenuation of samples 1, 21 and 30. Sample 1, the regular RG-214/U construction, has the highest attenuation of the three and increases above its calculated attenuation at frequencies above 3 GC. Sample 21, manufactured with a smaller size silver plated braid strand than sample 1, offers approximately 4% attenuation improvement from 10 MC to 3 GC. Above 3 GC the improvement increases to 40% at 10 GC. This particular sample of RG-214/U (sample 1), however, measured slightly higher than the average RG-214/U attenuation from 3 to 10 GC, so sample 21 probably does not offer quite 40% improvement to the cable design at 10 GC. The measured attenuation of sample 21 closely follows its computed values. Sample 30, which is RG-214/U core with a double silver plated ribbon braid, offers over 20% less attenuation than RG-214/U across the entire test frequency band of 10 MC to 10 GC. The measured attenuation of sample 30 agrees with its calculated attenuation at low frequencies but is less than calculated at higher frequencies. A comparison of the measured and calculated attenuation curves (graphs 1.26, page 35) indicates the dissipation factor used in the calculations is higher than actual. Note the measured attenuation above 500 MC of sample 30 and the measured value of the RG-217/U is higher than calculated. This shows the ribbon braid over a .285 inch dielectric yields an attenuation as good as or better than a standard braided .370 inch dielectric, a savings of 23% in core diameter. The ribbon braid also decreases the braid thickness.

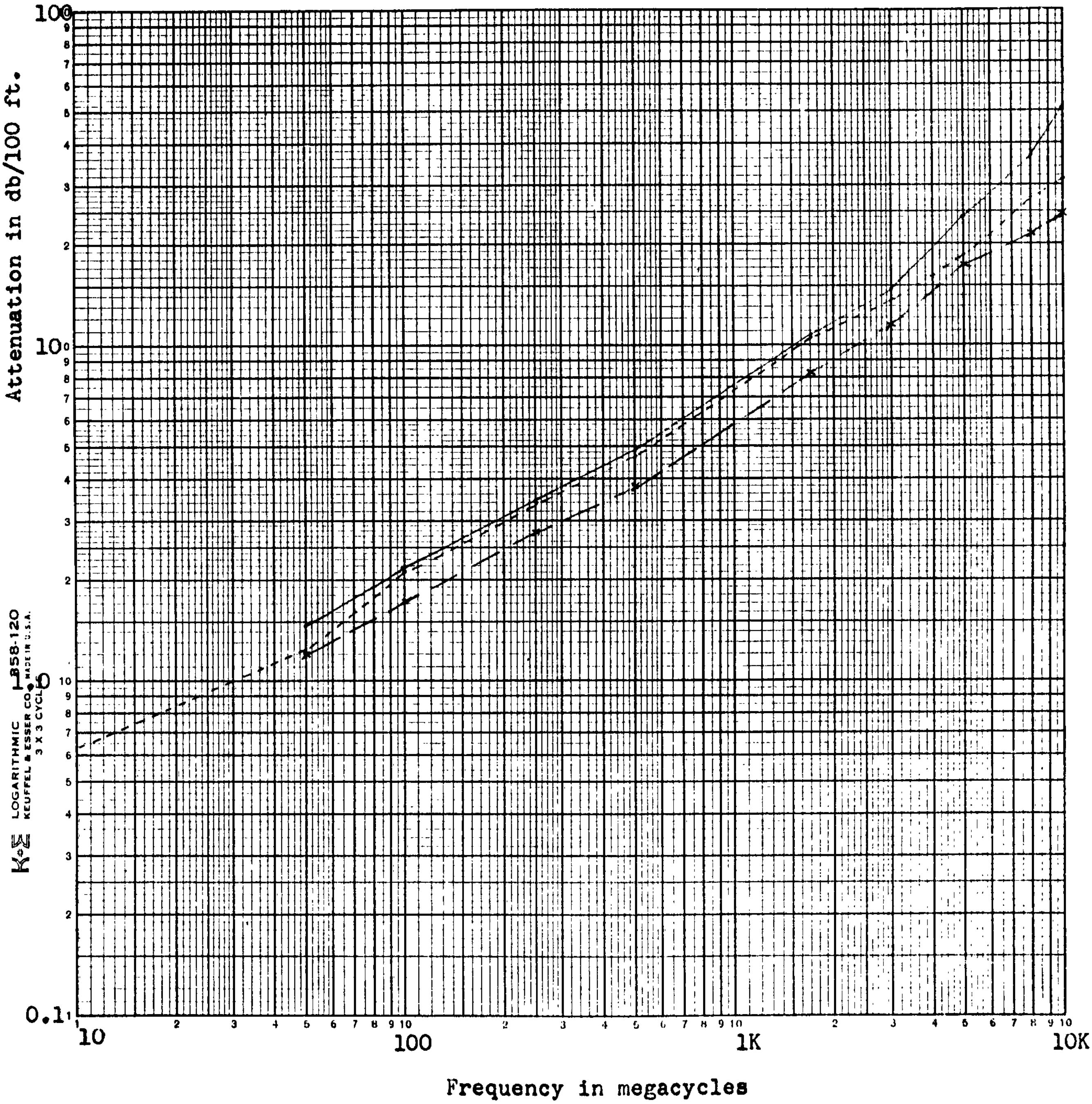
1.3.4.2 Discussion of attenuation test results on samples 3 and 22 - Graph 1.31, page 41, shows the measured attenuation of sample 3, which is regular RG-218/U, and sample 22, which has a silver plated braid over RG-218/U core. The two samples have approximately the same attenuation from 10 MC to 3 GC. At 3 GC the attenuation of sample 3 begins to increase rapidly until, at 10 MC, it is three times the attenuation of sample 22, which has followed the curve of its calculated values. This shows the high frequency attenuation of the large (.680 inch dielectric) can be improved, even though it is large enough to transmit higher modes at frequencies above 5.7 GC. (The TE_{10} above 5.7 GC and the TE_{01} above 8.04 GC) Over half the attenuation of sample 22 at 10 GC is caused by dielectric losses.

Text continued on page 42

Graph 1.30 - Measured attenuation of samples 1, 21 and 30 (RG-214/U size)

KEY

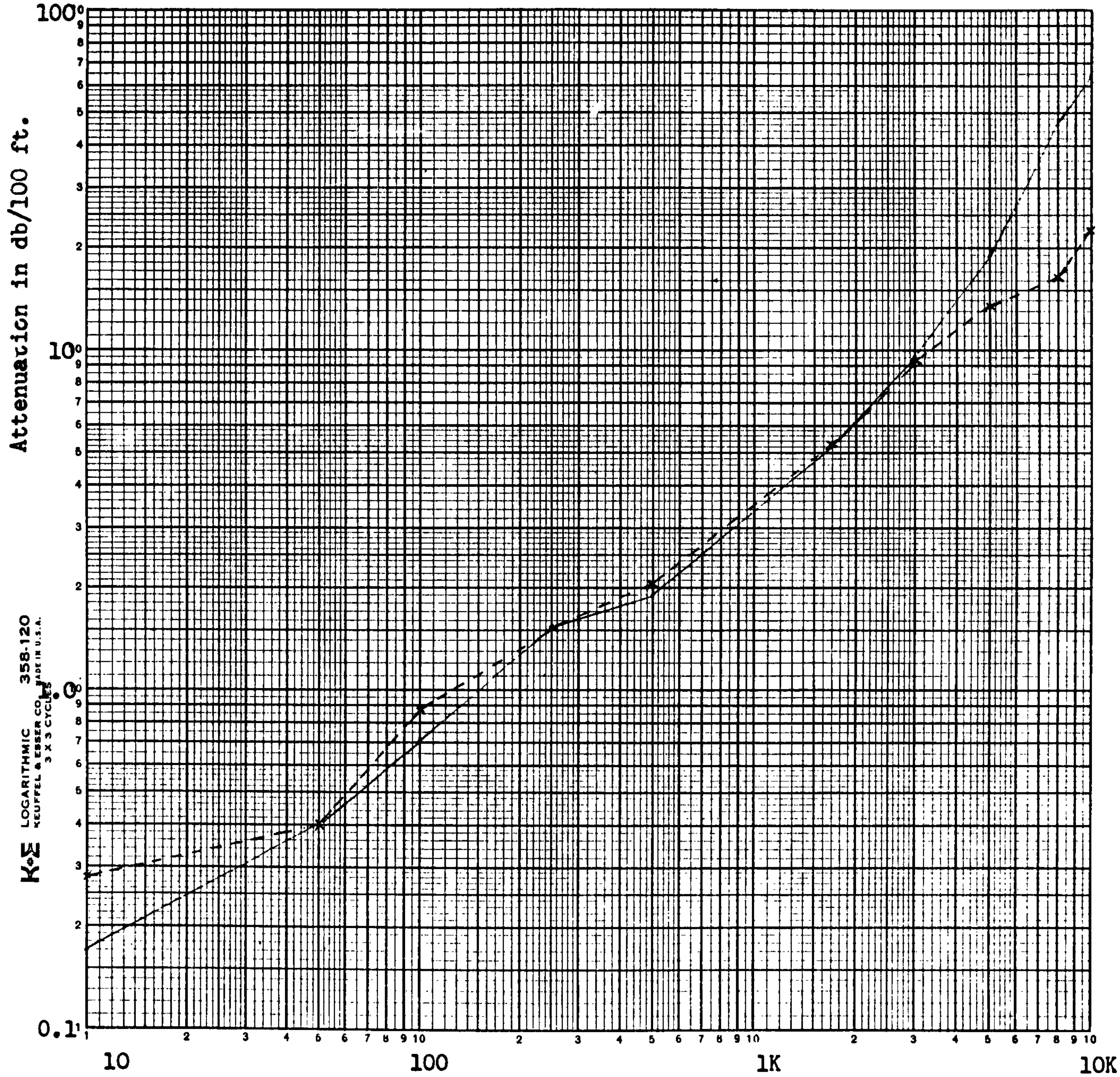
—— sample 1 (RG-214/U)
---- sample 21
x--x sample 30



Graph 1.31 - Measured attenuation of samples 3 and 22 (RG-218/U size)

KEY

—— sample 3 (RG-218/U)
x----x sample 22



Frequency in megacycles

1.3.4.3 Discussion of attenuation test results on sample 7 and 8 - Graph 1.32, page 43, presents the measured attenuation of samples 7 and 8 compared to the measured attenuation of sample 2, which is regular RG-217/U. Sample 7 shows the improved high frequency attenuation characteristic of a silver plated small size braid wire over the larger size bare copper wire. The increased low frequency attenuation of the small size wire is also shown. Sample 8 shows how the high frequency attenuation is increased when the silver plate is omitted.

1.3.4.4 Discussion of attenuation test results on samples 11 and 12 - Graph 1.33, page 44, shows the increased attenuation of the braided center conductor construction of samples 11 and 12 over the solid center conductor construction of sample 7.

1.3.4.5 Discussion of attenuation test results on samples 10 and 13 - Graph 1.34, page 45, shows the increased attenuation of sample 10, caused by the 19 strand, stranded center conductor. It also shows the attenuation of sample 13, which has the same center conductor as RG-217/U but a cellular polyethylene dielectric with a smaller diameter than RG-217/U. Sample 13 shows how a cellular polyethylene dielectric can decrease the size of the cable and yield the same attenuation. The size may be kept constant and the attenuation decreased by the same techniques.

1.3.4.6 Discussion of attenuation test results on sample 17 - Graph 1.35, page 46, shows the improved attenuation of the flat copper braid of sample 17 compared to the attenuation of sample 7.

1.3.4.7 Discussion of attenuation test results on samples 31, 32 and 33 - Graph 1.36, page 47, shows the braid factor does not completely describe the attenuation characteristics of samples 31, 32 and 33. Samples 31 and 32 have the same braid factor as sample 7 while sample 33 has a smaller braid factor. Apparently, other variables, such as braid angle, must be considered to accurately predict the attenuation characteristics of a braid. The results, however, also show the braid factor predicts the braid's contribution to the attenuation to accuracies compatible to manufacturing tolerances.

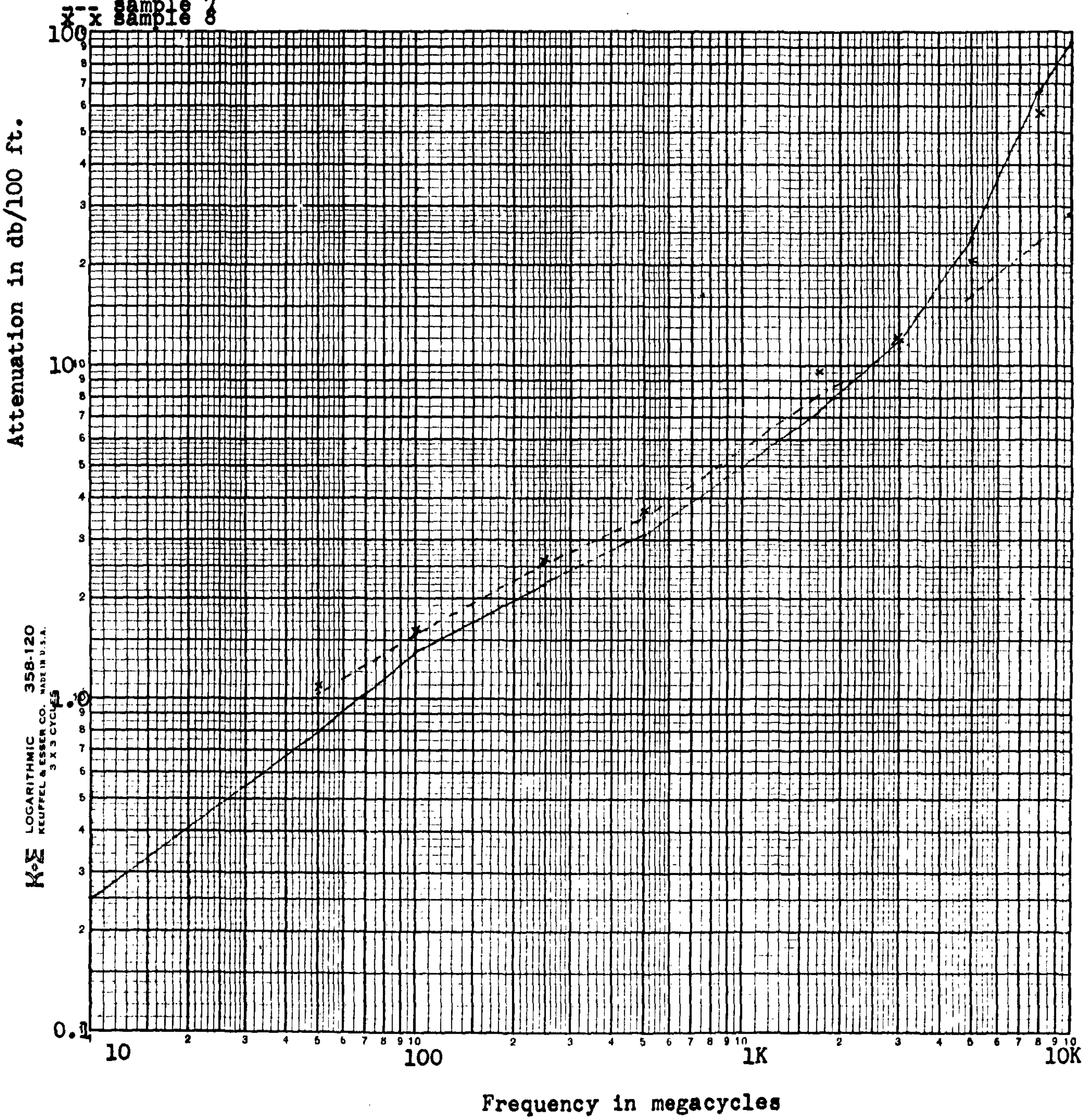
1.3.4.8 Discussion of attenuation test results on other samples - The attenuation of sample 15 (graph 1.13, page 22) is much too high for consideration in this application. The increased attenuation is caused by the high dissipation of the elastomeric polyethylene and eliminates the material for use as a coaxial dielectric, but it could be employed in the manufasture of an isolation cable. Sample 18, 20 and 23 through 29 were manufactured for evaluation of jacketing material and their attenuation do not contribute to the discussion. Their attenuation had to be measured, however, to examine the contamination effect of the jacketing material.

Text continued on page 48

Graph 1.32 - Measured attenuation of samples 2, 7 and 8 (RG-217/U size)

KEY

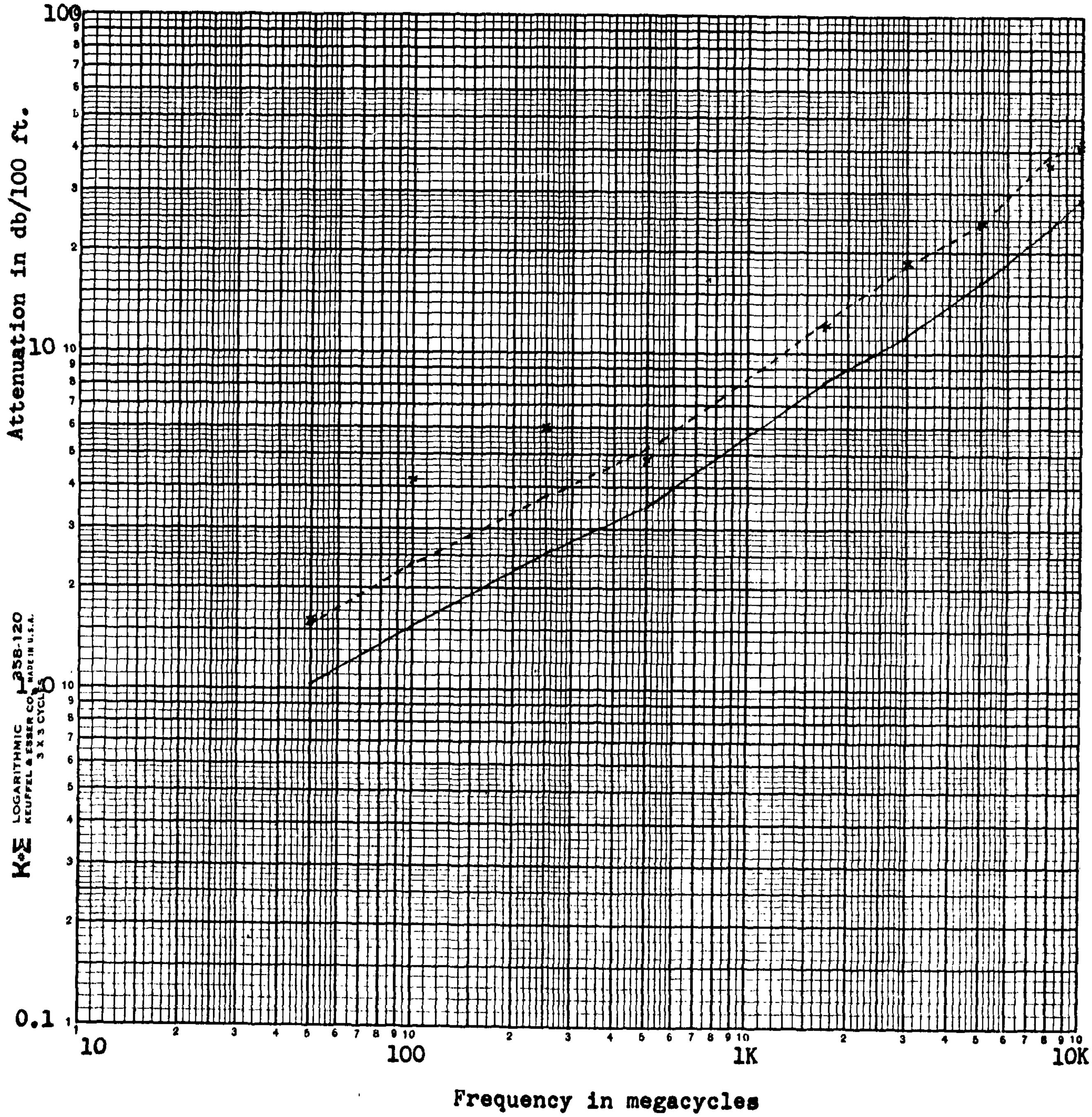
—— sample 2 (RG-217/U)
--- sample 7
x x sample 8



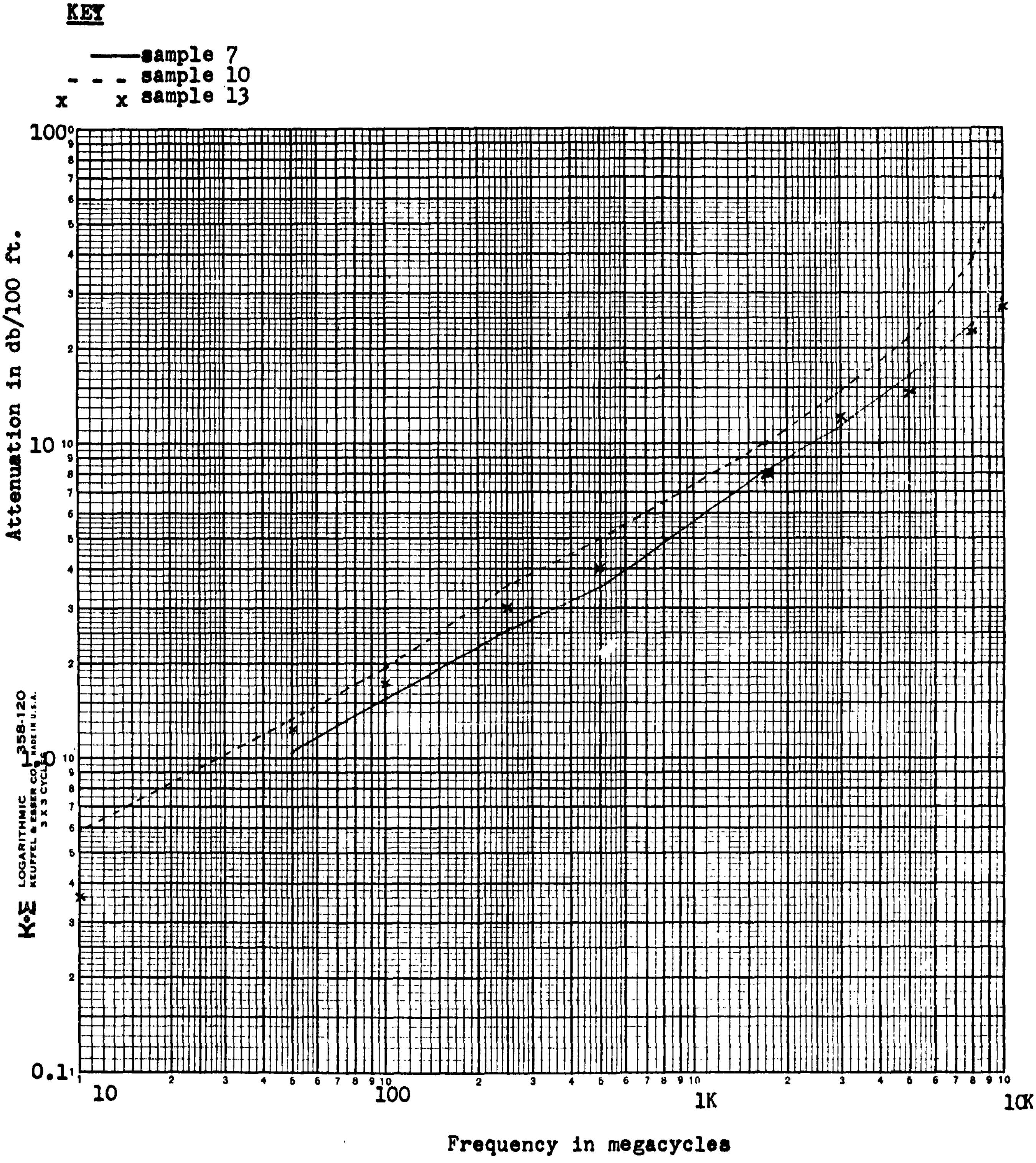
Graph 1.33 - Measured attenuation of samples 7, 11 and 12 (RG-217/U size)

KEY

—— sample 7
- - - sample 11
x x sample 12



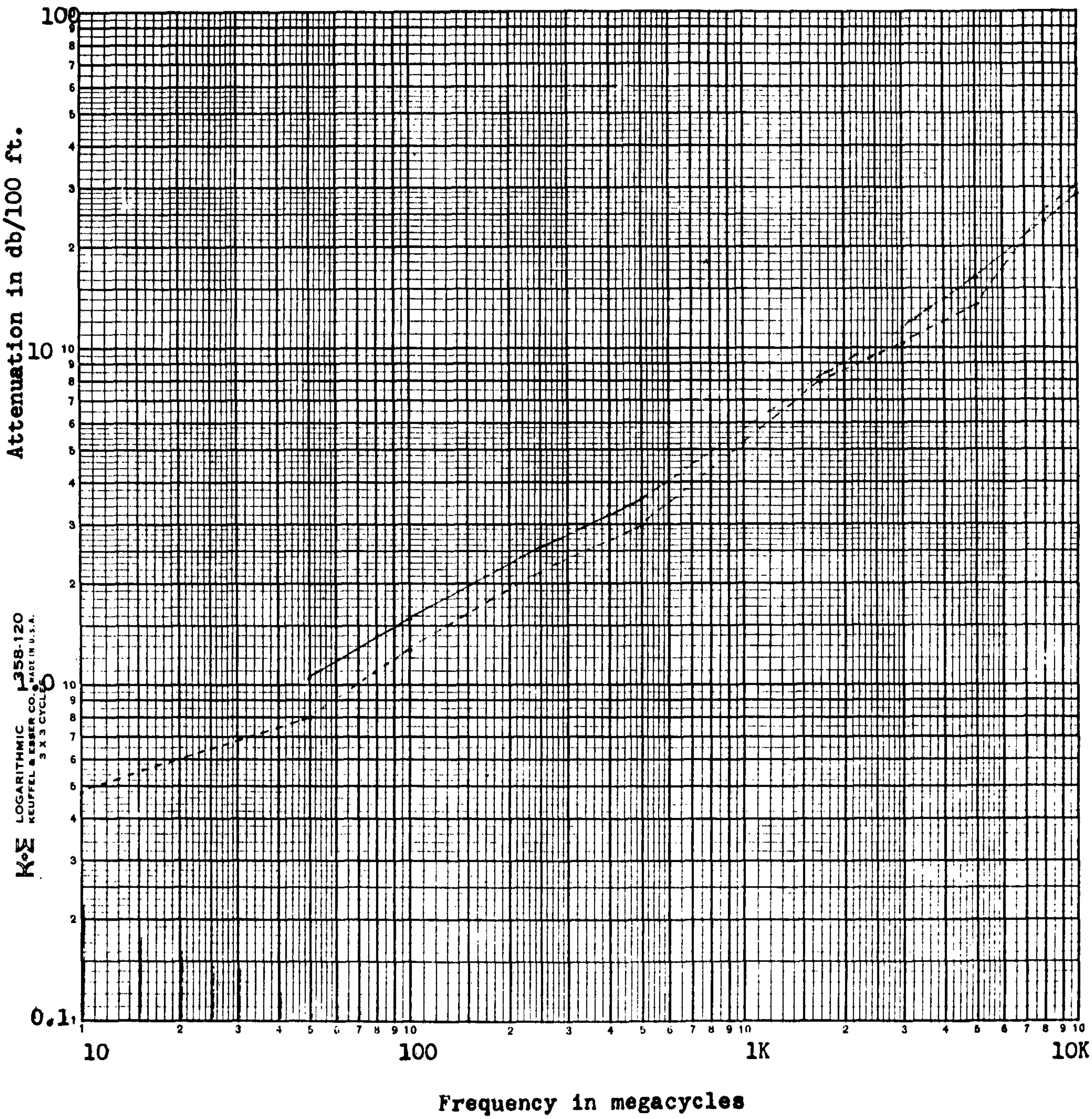
Graph 1.34 - Measured attenuation of samples 7, 10 and 13 (RG-217/U size)



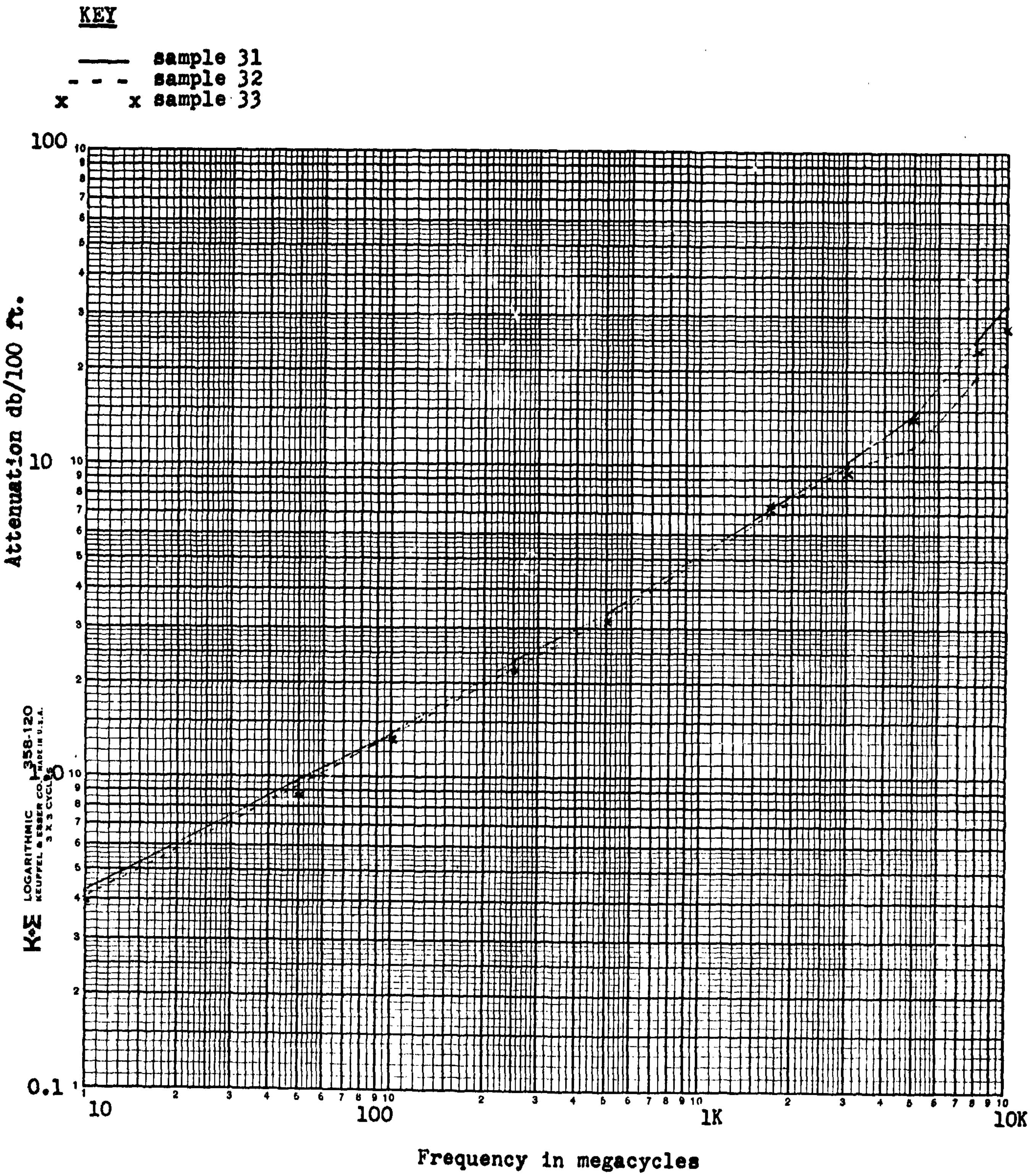
Graph 1.35 - Measured attenuation of samples 7 and 17 (RG-217/U size)

KEY

—— sample 7
- - - sample 17



Graph 1.36 - Measured attenuation of samples 31, 32 and 33 (RG-217/U size)



1.3.5 VSWR test results - Table 1.3, page 49, lists the measured voltage standing wave ratio (VSWR) of the samples at 1.7, 3.0, 5.0, 8.0 and 10.0 GC.

1.3.6 Discussion of VSWR test results - The VSWR of the samples, measured at the same frequency and time the high frequency attenuation measurements were made, indicate the cable mismatch at these frequencies. These mismatches indicate the nominal impedance of the cable, the uniformity of the cable, and the amount of the measured insertion loss that is not caused by the attenuation of the cable.

1.3.7 Stability test results - The stability test results are presented in table 1.4, pages 50 and 51, and in graphs 1.37 through 1.54, pages 52-69. The stability is measured by comparing the measured high frequency attenuation of the cable after manufacture, after heat aging, after flexing and after cold bending. The contamination test of MIL-C-17C consists of the first two steps. The graphs are arranged, with two cable stability test results on each graph, in a manner to aid the discussion of the results.

1.3.8 Discussion of stability test results - Graph 1.40 shows the stability of sample 2, which is RG-217/U and sample 7, which is RG-217/U core with a silver plated 36 gauge strand braid. The much improved stability of sample 7 indicates a silver plated braid is a more stable construction. Graph 1.41 shows the stability of samples 7 and 8, which are identical constructions except sample 7 has a silver plated braid and sample 8 has a bare copper braid. Graph 1.49 shows this is also true on other size cables since sample 3 is regular RG-218/U and sample 22 is a silver plated braid version of RG-218/U. Graphs 1.51, 1.52 and 1.53 show the difference between a contaminative type instability and instability that is caused by the braid construction. Samples 24, 26 and 28 have polyvinyl jackets while samples 25, 27 and 29 have noncontaminating polyvinyl jackets. Heat aging of samples 24, 26 and 28 caused a large attenuation increase regardless of the braid construction; silver, bare or tinned copper. Heat aging caused little attenuation increase on samples 25 and 29, which have silver and tinned copper braid respectively, bud did cause some on the bare copper construction of sample 27. Sample 27 failed the contamination test of Mil-C-17 because its attenuation at 3 GC after heat aging (14 db) is more than 15% of its original attenuation (12 db) even though 14 db is maximum at 3 GC. This is common with bare copper braided polyethylene cores. The two increases apparently have different causes. In one case the polyvinyl jacket affects the attenuation by contaminating the polyethylene dielectric and increasing its dissipation factor, while the noncontaminating jacket does not affect the dielectric but the heat affects the bare copper braid, perhaps by corrosion.

Text continued on page 70

Table 1.3 VSWR test results

Sample No.	Frequency in Gigacycles				
	1.7	3.0	5.0	8.0	10.0
1	1.07	1.08	1.15	1.27	1.40
2	1.06	1.08	1.14	1.26	1.34
3	1.18	1.15	1.02	1.14	1.18
4	1.10	1.10	1.19	1.20	1.40
5	1.12	1.29	1.20	1.24	1.31
6	1.02	1.06	1.03	1.12	1.27
7	1.14	1.09	1.18	1.55	1.40
8	1.06	1.11	1.17	1.30	1.41
9					
10	1.22	1.22	1.12	1.45	1.55
11	1.21	1.12	1.09	1.32	1.40
12	1.37	1.15	1.10	1.45	1.28
13	1.13	1.16	1.55	1.58	1.53
14					
15	1.10	1.11	1.29	1.20	1.23
16					
17	1.02	1.13	1.20	1.50	1.40
18	1.06	1.02	1.45	1.21	1.23
19					
20	1.05	1.18	1.38	1.21	1.30
21	1.08	1.03	1.03	1.17	1.22
22	1.34	1.52	1.58	1.29	1.62
23	1.09	1.11	1.18	1.26	1.54
24	1.04	1.20	1.28	1.22	1.14
25	1.07	1.17	1.29	1.10	1.22
26	1.04	1.09	1.28	1.36	1.21
27	1.03	1.21	1.08	1.22	1.38
28	1.00	1.07	1.21	1.37	1.32
29	1.06	1.15	1.19	1.28	1.27
30	1.13	1.24	1.39	1.54	1.59

Table 1.4 - Stability Test Results (Attenuation in db/100 ft)

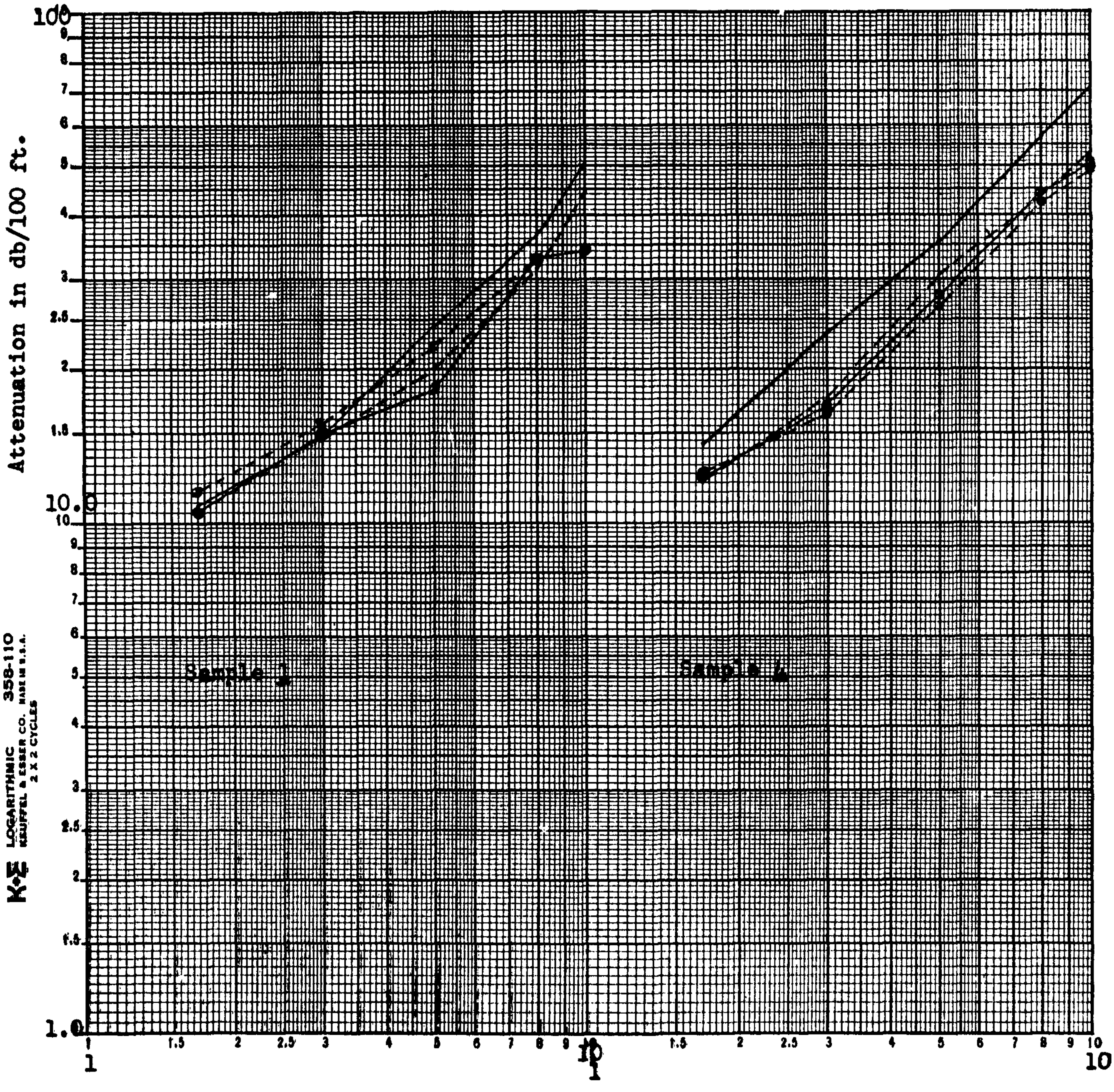
Sample No.	Conditioning	Frequency in Gigacycles				
		1.7	3.0	5.0	8.0	10.0
1	Manufacturing	10.82	14.70	24.22	36.33	50.75
	Heat Aged	10.60	15.00	18.45	33.00	34.10
	Flexed	10.60	14.65	20.00	31.60	44.60
	Cold Bend	11.60	15.70	22.20	32.90	33.20
2	Manufacturing	7.24	11.75	24.00	65.70	92.40
	Heat Aged	9.28	16.00	28.00	88.56	156.00
	Flexed	10.38	16.41	32.31	102.00	185.60
	Cold Bend	10.48	16.00	36.00	109.44	160.00
3	Manufacturing	5.23	9.55	18.90	47.60	64.70
	Heat Aged	7.75	17.50	125.00	---	---
	Flexed	7.58	15.33	120.00	---	107.5
	Cold Bend	8.11	17.90	115.00	135.00	105.00
4	Manufacturing	14.30	23.60	35.40	57.00	71.30
	Heat Aged	12.41	17.02	28.00	44.00	50.62
	Flexed	12.14	17.64	30.61	43.60	53.16
	Cold Bend	12.55	16.41	26.56	42.40	49.10
5	Manufacturing	10.10	13.60	23.50	62.20	87.20
	Heat Aged	9.08	13.04	18.94	44.88	56.88
	Flexed	9.47	13.04	18.94	60.44	116.00
	Cold Bend	16.67	26.60	65.80	95.32	156.00
6	Manufacturing	6.43	9.92	18.90	45.40	64.70
	Heat Aged	5.72	12.20	56.50	---	95.00
	Flexed	9.26	18.88	68.88	156.00	156.00
	Cold Bend	6.18	12.47	44.20	90.00	97.50
7	Manufacturing	8.20	11.30	16.20	23.90	28.60
	Heat Aged	7.75	10.65	12.30	25.00	24.20
	Flexed	8.10	11.40	13.40	25.00	32.40
	Cold Bend	8.45	12.80	17.50	21.60	30.60
8	Manufacturing	9.68	12.00	20.70	57.70	111.5
	Heat Aged	15.30	20.90	20.00	35.04	42.60
	Flexed	14.20	18.70	18.30	32.76	43.10
	Cold Bend	15.60	14.60	20.00	40.00	76.00
10	Manufacturing	10.00	14.95	21.50	38.20	72.40
	Heat Aged	9.87	14.11	17.90	40.00	41.92
	Flexed	10.58	14.33	19.16	44.88	112.00
	Cold Bend	10.48	14.82	21.20	41.60	62.14
11	Manufacturing	12.40	18.30	24.30	39.20	42.60
	Heat Aged	11.90	17.90	21.90	45.80	67.70
	Flexed	12.30	19.20	32.50	44.00	87.50
	Cold Bend	12.40	18.80	29.10	48.80	59.20
12	Manufacturing	12.10	18.50	24.20	36.10	41.20
	Heat Aged	11.90	17.40	19.10	31.60	34.90
	Flexed	13.40	18.95	21.90	35.00	47.20
	Cold Bend	13.50	17.50	24.50	35.00	43.40
13	Manufacturing	8.00	12.00	14.50	22.20	27.00
	Heat Aged	9.16	11.36	18.10	28.00	29.20
	Flexed	8.96	12.44	16.43	32.00	30.28
	Cold Bend	8.76	12.00	15.66	26.28	26.00

15	Manufacturing	176.4	250.0	340.0	461.6	600.0
	Heat Aged	180.0	260.0	351.1	482.5	572.0
	Flexed	169.4	230.9	346.7	487.5	540.0
	Cold Bend	183.7	273.3	353.3	470.8	520.0
17	Manufacturing	8.00	10.20	13.40	25.70	30.20
	Heat Aged	8.00	9.68	35.42	192.00	136.00
	Flexed	7.56	13.76	41.20	85.52	85.52
	Cold Bend	7.55	15.70	36.00	47.56	53.48
18	Manufacturing	8.56	10.10	16.00	25.40	38.20
	Heat Aged	8.96	10.97	18.52	27.43	42.52
	Flexed	9.16	12.15	15.13	28.00	64.88
	Cold Bend	8.46	12.00	15.30	26.86	36.28
20	Manufacturing	9.16	12.30	17.70	33.60	65.20
	Heat Aged	8.96	12.59	15.30	35.62	54.84
	Flexed	9.16	12.30	16.00	36.88	68.87
	Cold Bend	8.96	12.15	16.00	27.43	41.08
21	Manufacturing	10.70	13.60	18.50	27.60	31.00
	Heat Aged	11.08	14.22	19.36	28.70	30.28
	Flexed	10.40	13.48	18.94	29.76	29.76
	Cold Bend	11.50	14.33	21.25	32.95	30.48
22	Manufacturing	5.36	9.32	13.40	16.30	22.60
	Heat Aged	5.00	7.50	14.70	29.40	34.20
	Flexed	5.23	9.63	11.10	20.00	28.90
	Cold Bend	5.28	8.15	12.25	19.70	31.40
23	Manufacturing	8.95	12.00	18.50	39.50	85.00
	Heat Aged	8.95	12.30	14.90	27.20	29.40
	Flexed	8.76	12.60	15.70	29.80	36.80
	Cold Bend	8.88	13.04	20.52	36.40	54.30
24	Manufacturing	8.10	15.15	15.60	27.00	44.50
	Heat Aged	19.71	29.15	42.80	65.90	>75.0
	Flexed	21.45	30.82	43.90	63.75	97.50
	Cold Bend	21.60	30.60	43.40	67.50	87.60
25	Manufacturing	8.74	12.30	14.40	25.0	45.3
	Heat Aged	8.88	11.88	19.10	35.70	>75.0
	Flexed	8.63	13.50	19.33	34.05	65.10
	Cold Bend	9.57	13.80	22.50	35.00	51.80
26	Manufacturing	9.15	12.90	17.50	46.60	120.0
	Heat Aged	24.22	36.80	51.60	74.20	109.1
	Flexed	24.22	39.20	51.20	74.20	99.44
	Cold Bend	48.62	49.32	71.11	120.00	168.00
27	Manufacturing	8.64	12.00	18.80	45.70	119.0
	Heat Aged	12.96	14.21	20.48	40.00	65.48
	Flexed	12.40	16.00	22.60	40.80	56.88
	Cold Bend	14.07	17.02	25.28	43.20	76.00
28	Manufacturing	8.96	13.20	16.10	36.40	94.50
	Heat Aged	16.50	25.38	38.00	99.76	156.00
	Flexed	18.50	26.21	38.00	70.53	168.00
	Cold Bend	17.50	25.93	37.60	61.33	98.28
29	Manufacturing	8.96	13.60	15.10	40.00	76.00
	Heat Aged	9.98	13.77	22.25	53.28	148.80
	Flexed	10.48	14.33	22.00	40.00	69.56
	Cold Bend	10.38	15.40	20.75	38.22	69.91
30	Manufacturing	8.34	11.54	17.38	21.40	24.76
	Heat Aged	8.60	12.26	17.70	31.60	34.00
	Flexed	8.80	12.00	17.24	27.20	36.00
	Cold Bend	8.82	12.00	17.54	28.00	35.58

Graph 1.37 - Attenuation stability test results on samples 1 and 4

KEY

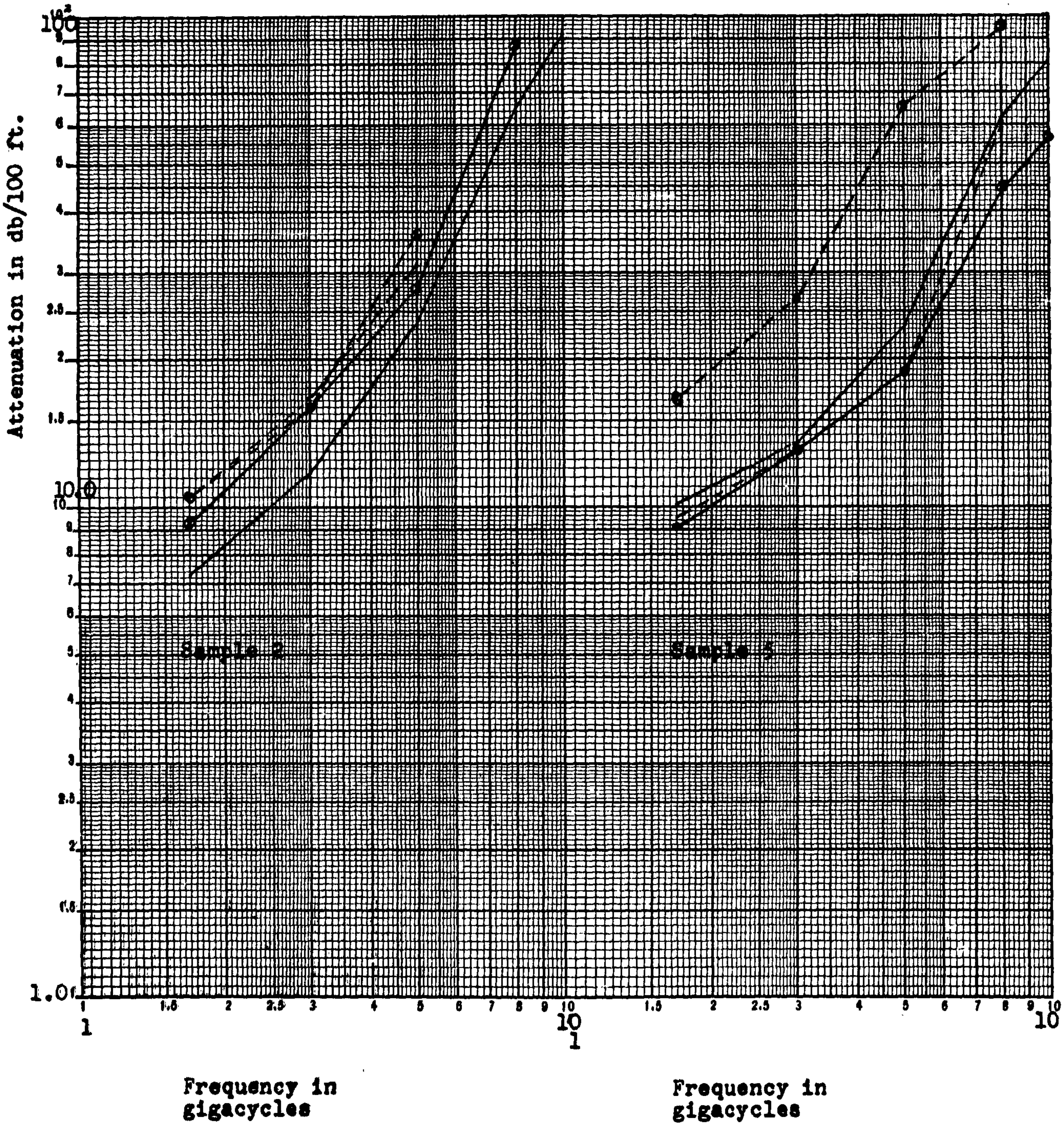
—— after manufacture
x - x after heat aged
---- after flex
x--x after cold bend



Graph 1.38 - Attenuation stability test results on samples 2 and 5.

KEY

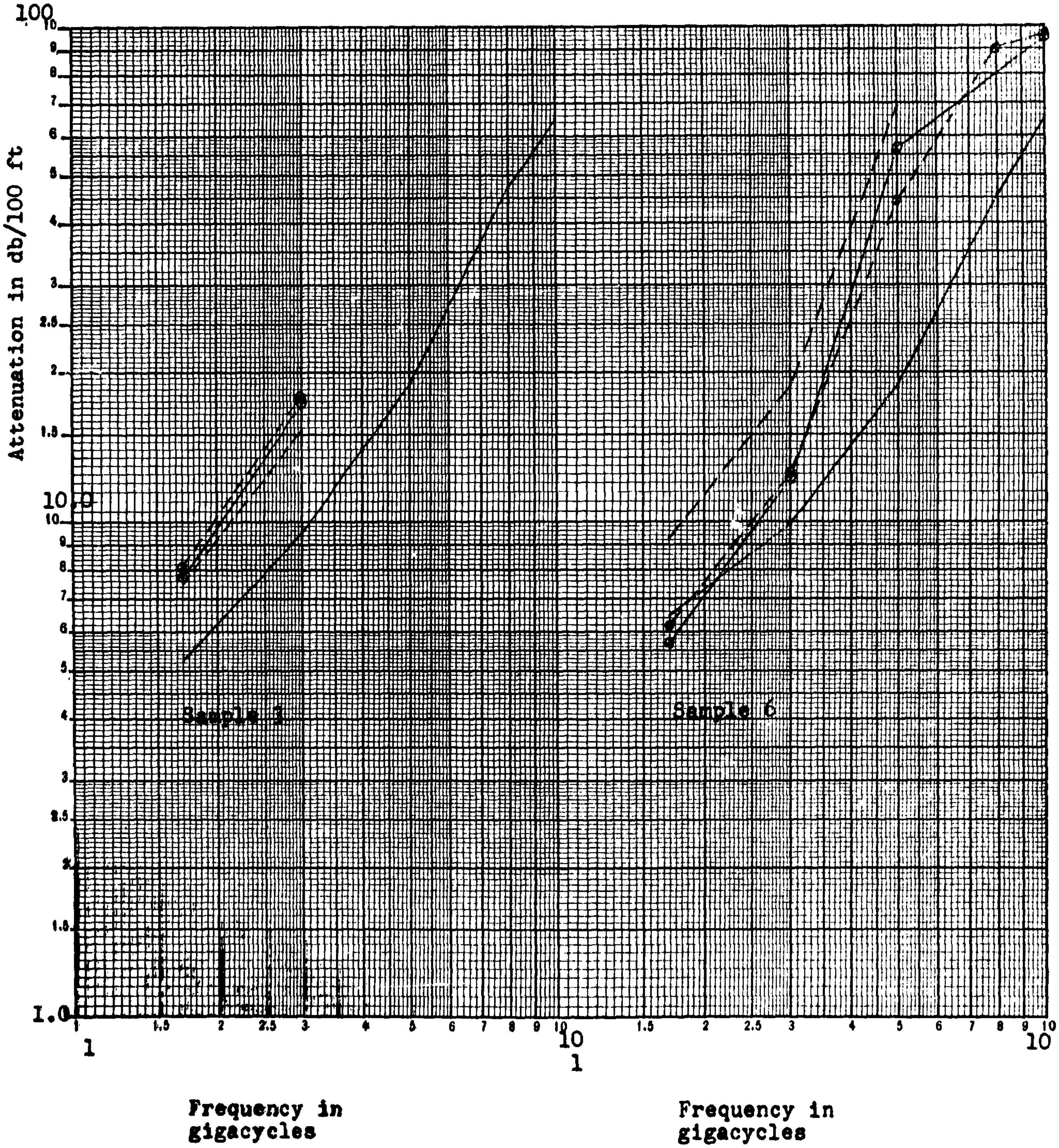
—— after manufacture
x - x after heat aged
------ after flex
x---x after cold bend



Graph 1.39 - Attenuation stability test results on samples 3 and 6.

KEY

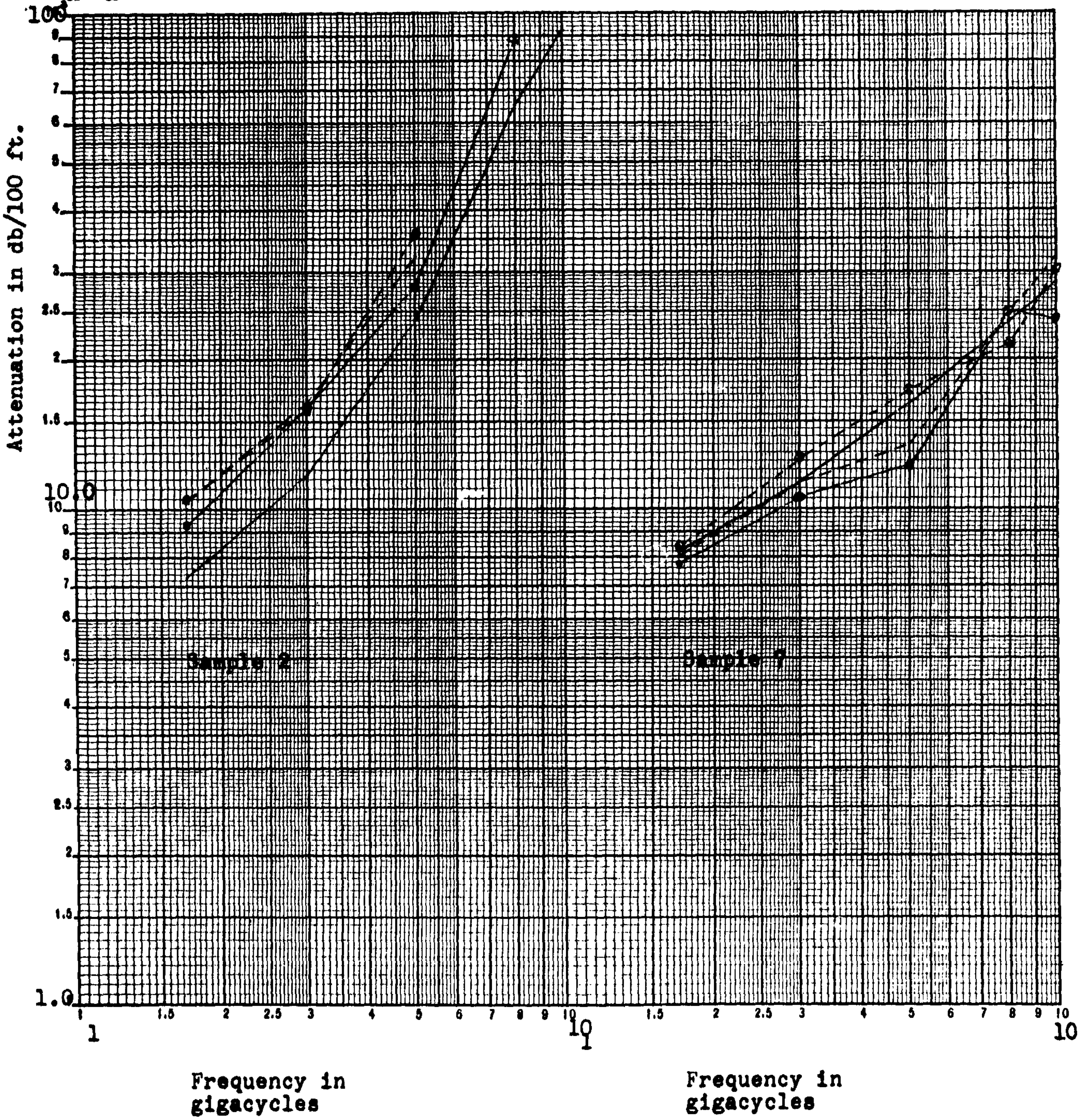
—— after manufacture
x——x after heat aged
------ after flex
x----x after cold bend



Graph 1.40 - Attenuation stability test results on samples 2 and 7.

KEY

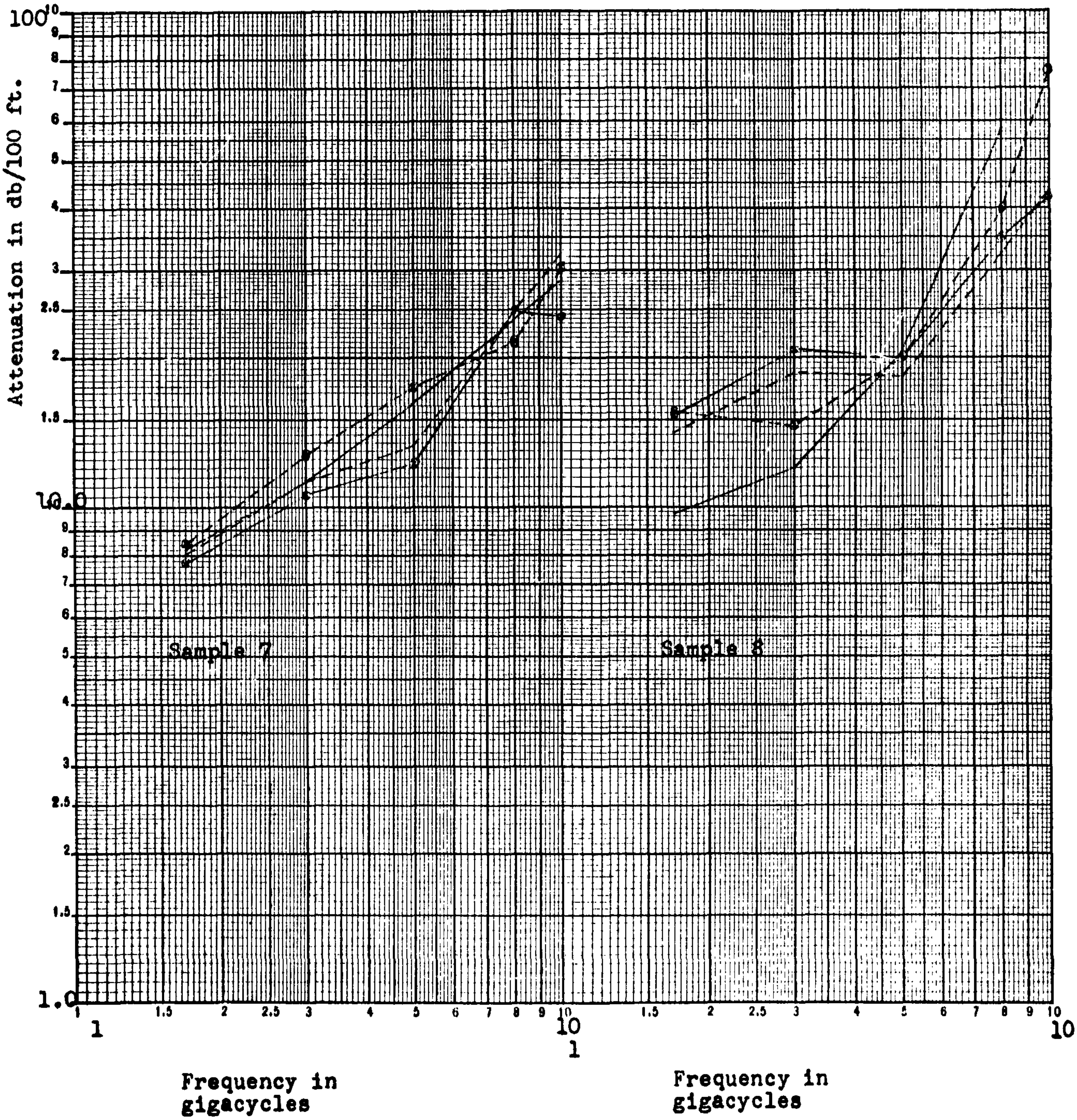
—— after manufacture
x——x after heat aged
--- after flex
x--x after cold bend



Graph 1.41 - Attenuation stability test results on samples 7 and 8.

KEY

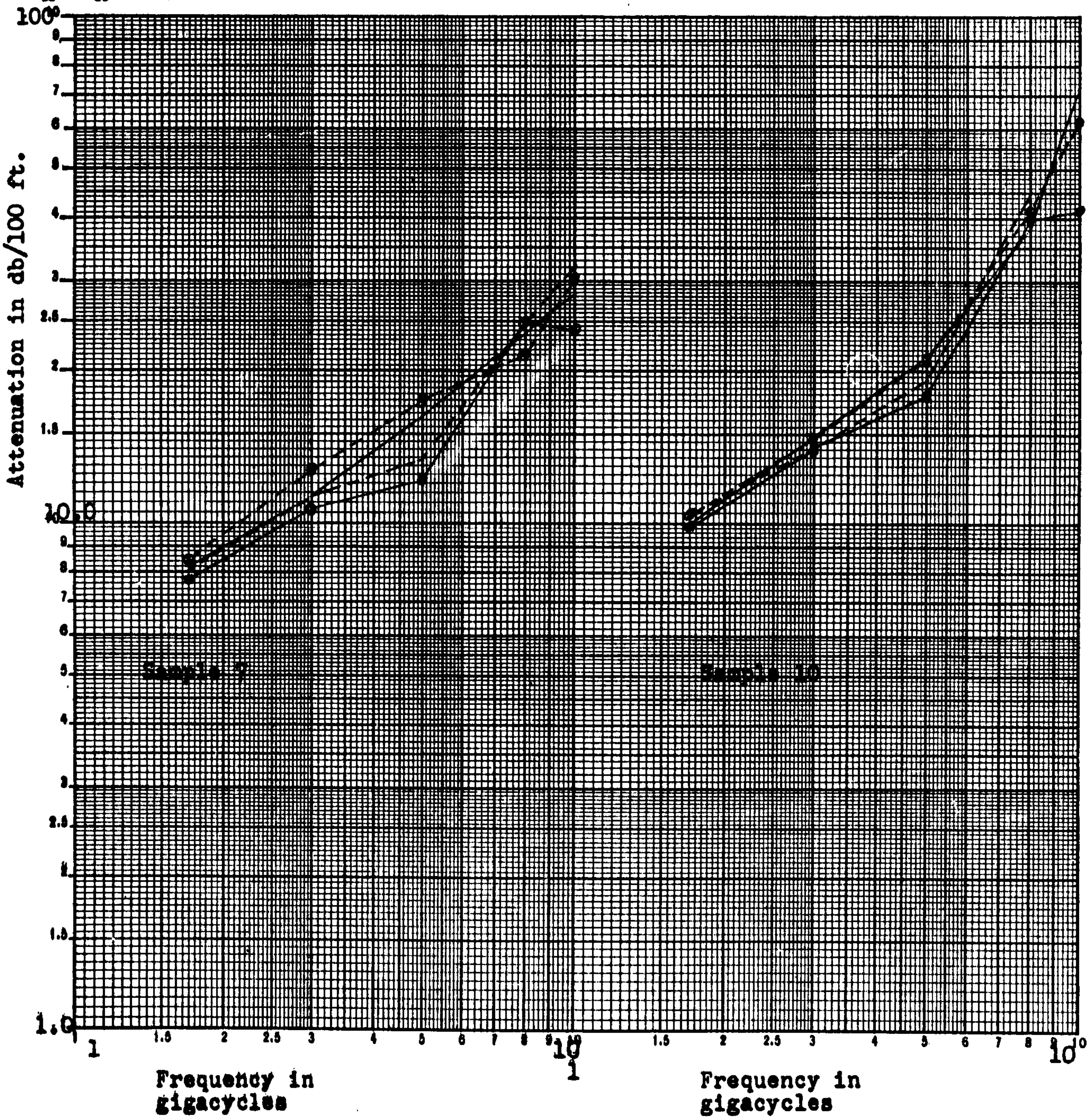
——— after manufacture
x——x after heat aged
----- after flex
x ---x after cold bend



Graph 1.42 - Attenuation stability test results on samples 7 and 10

KEY

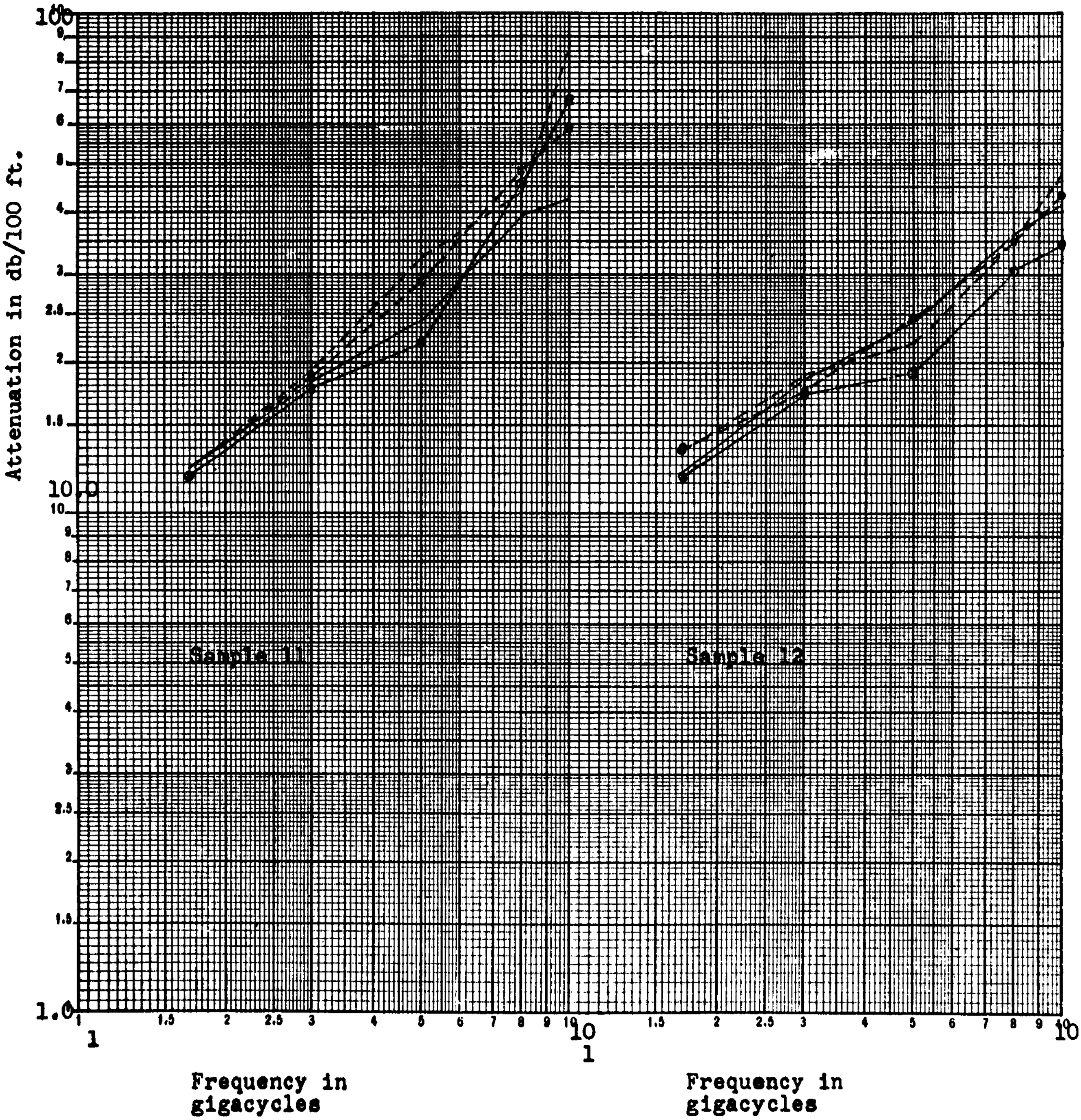
—— after manufacture
x——x after heat aged
----- after flex
x---x after cold bend



Graph 1.43 - Attenuation stability test results on samples 11 and 12.

KEY

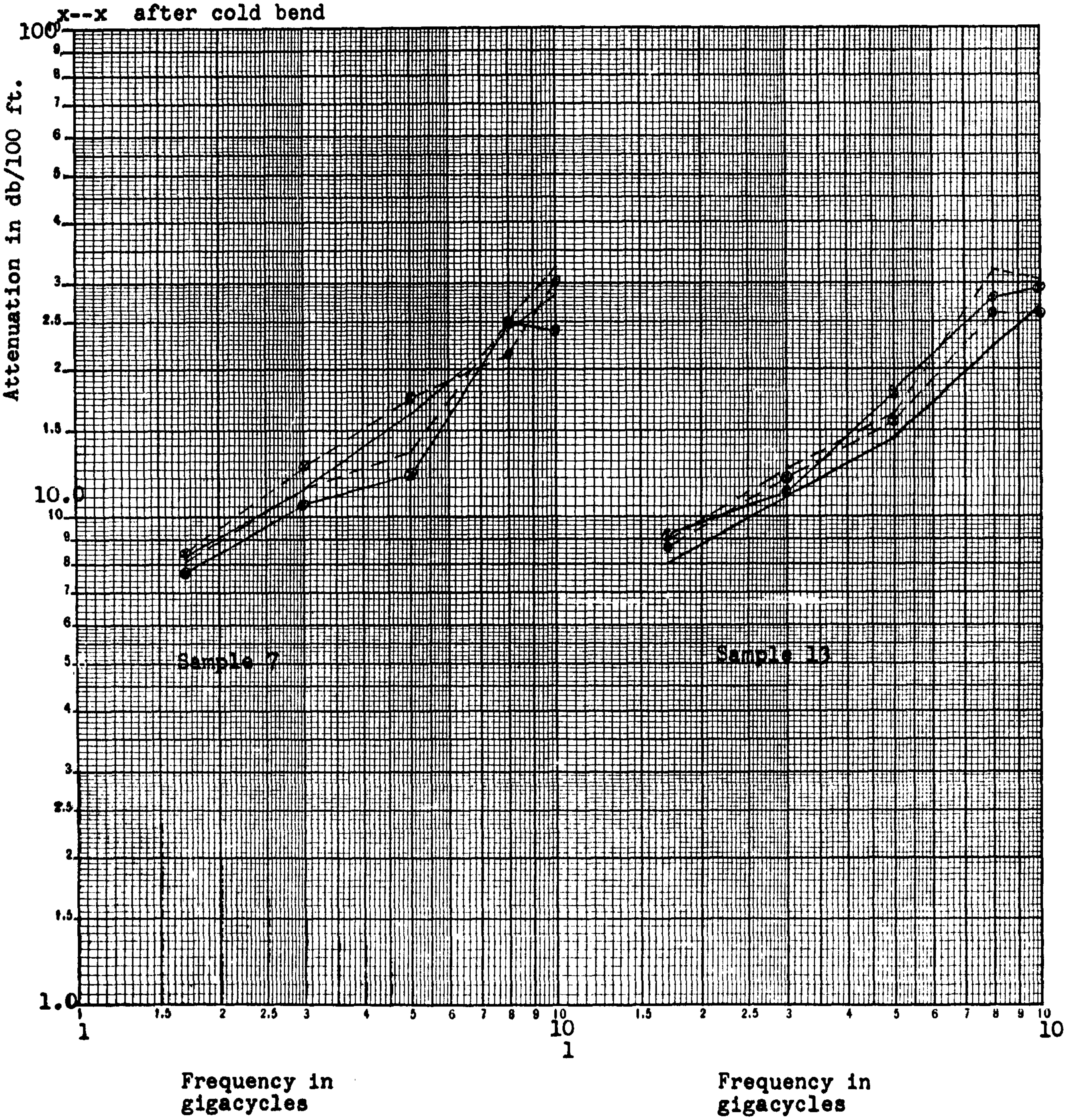
—— after manufacture
x—x after heat aged
----- after flex
x --x after cold bend



Graph 1.44 - Attenuation stability test results on samples 7 and 13.

KEY

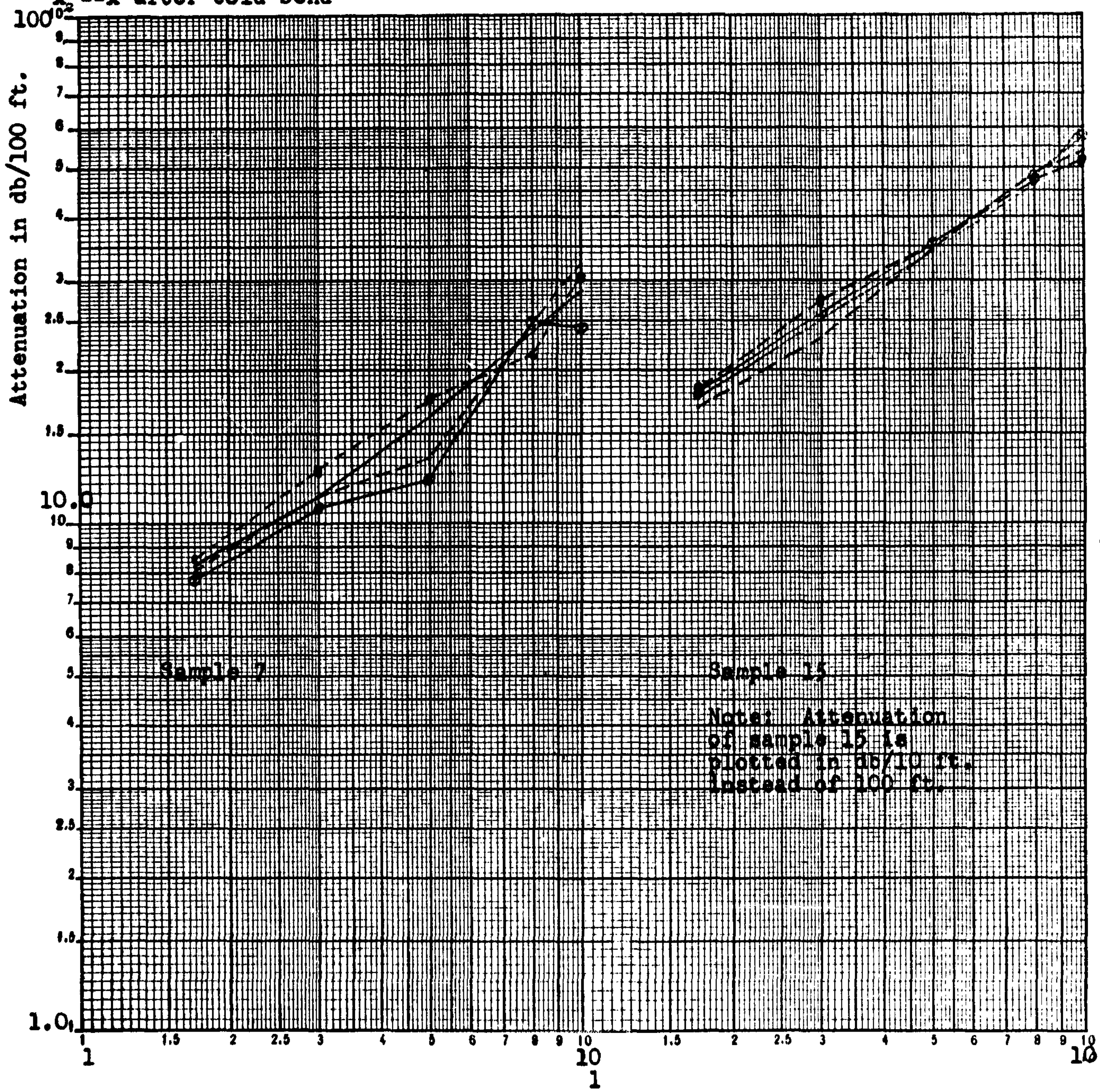
—— after manufacture
x - x after heat aged
---- after flex
x--x after cold bend



Graph 1.45 -Attenuation stability test results on samples 7 and 15.

KEY

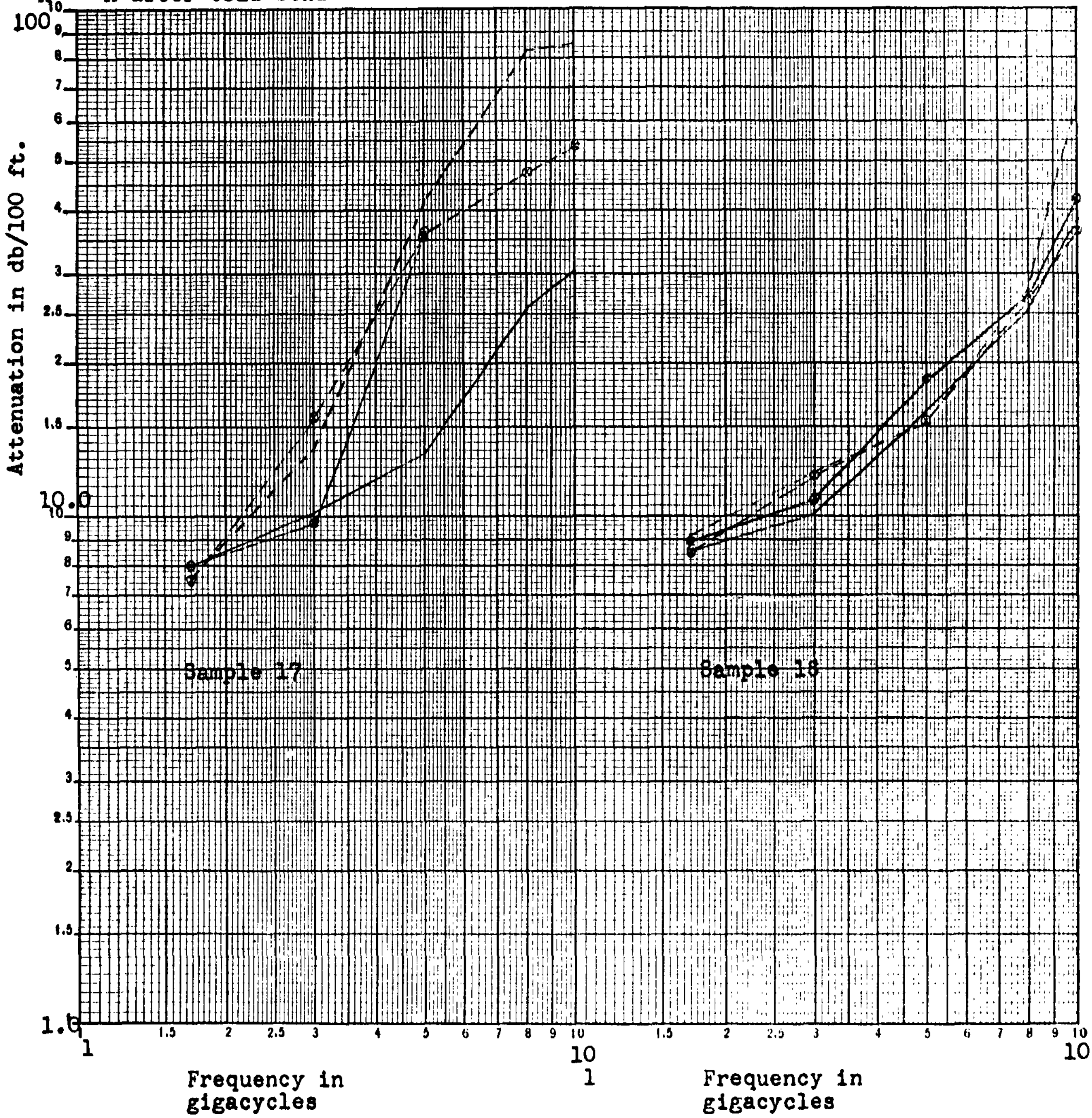
—— after manufacture
x -x after heat aged
---- after flex
x --x after cold bend



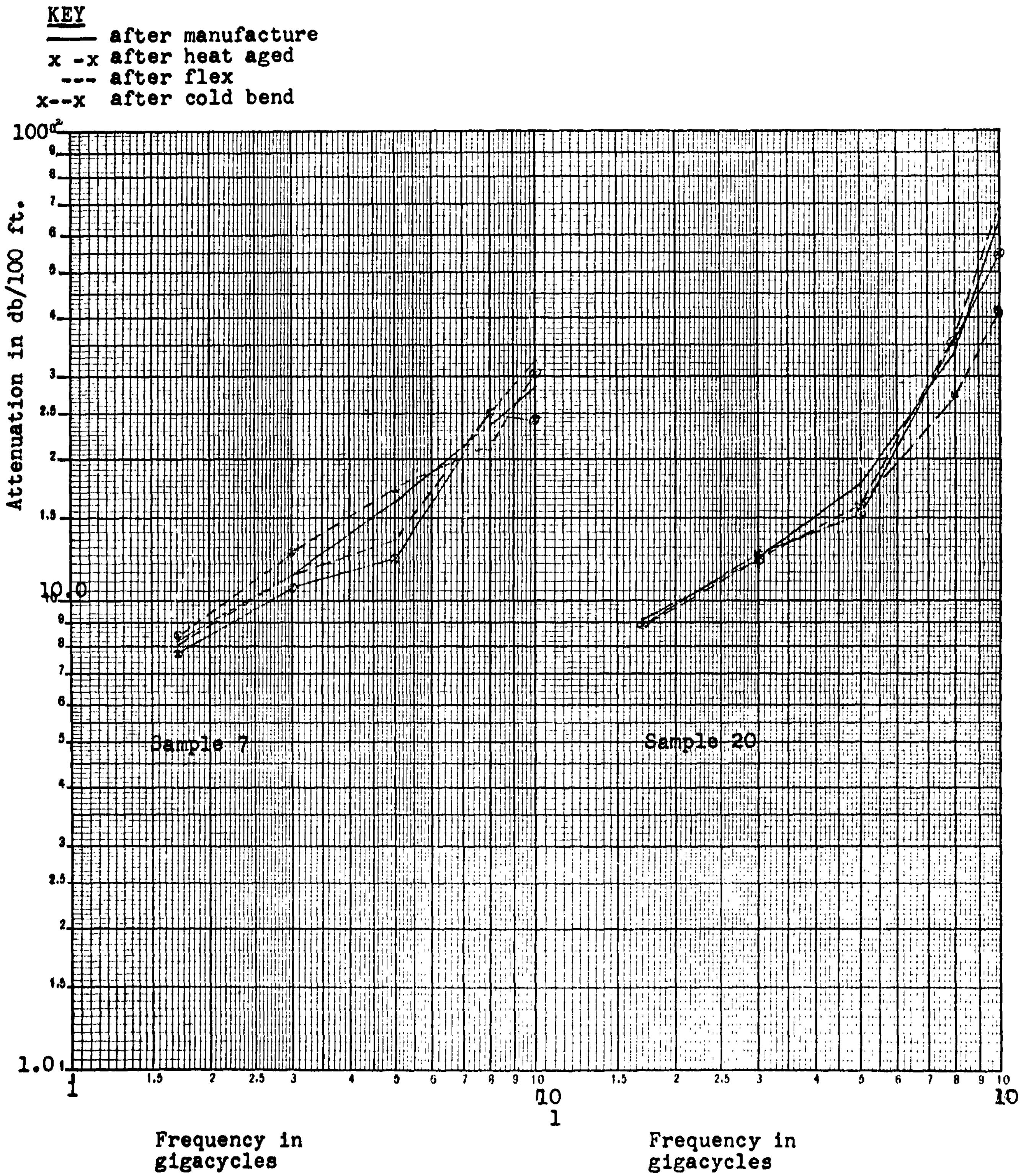
Graph 1.46 - Attenuation stability test results on samples 17 and 18.

KEY

____ after manufacture
x - x after heat aged
------ after flex
x---x after cold bend

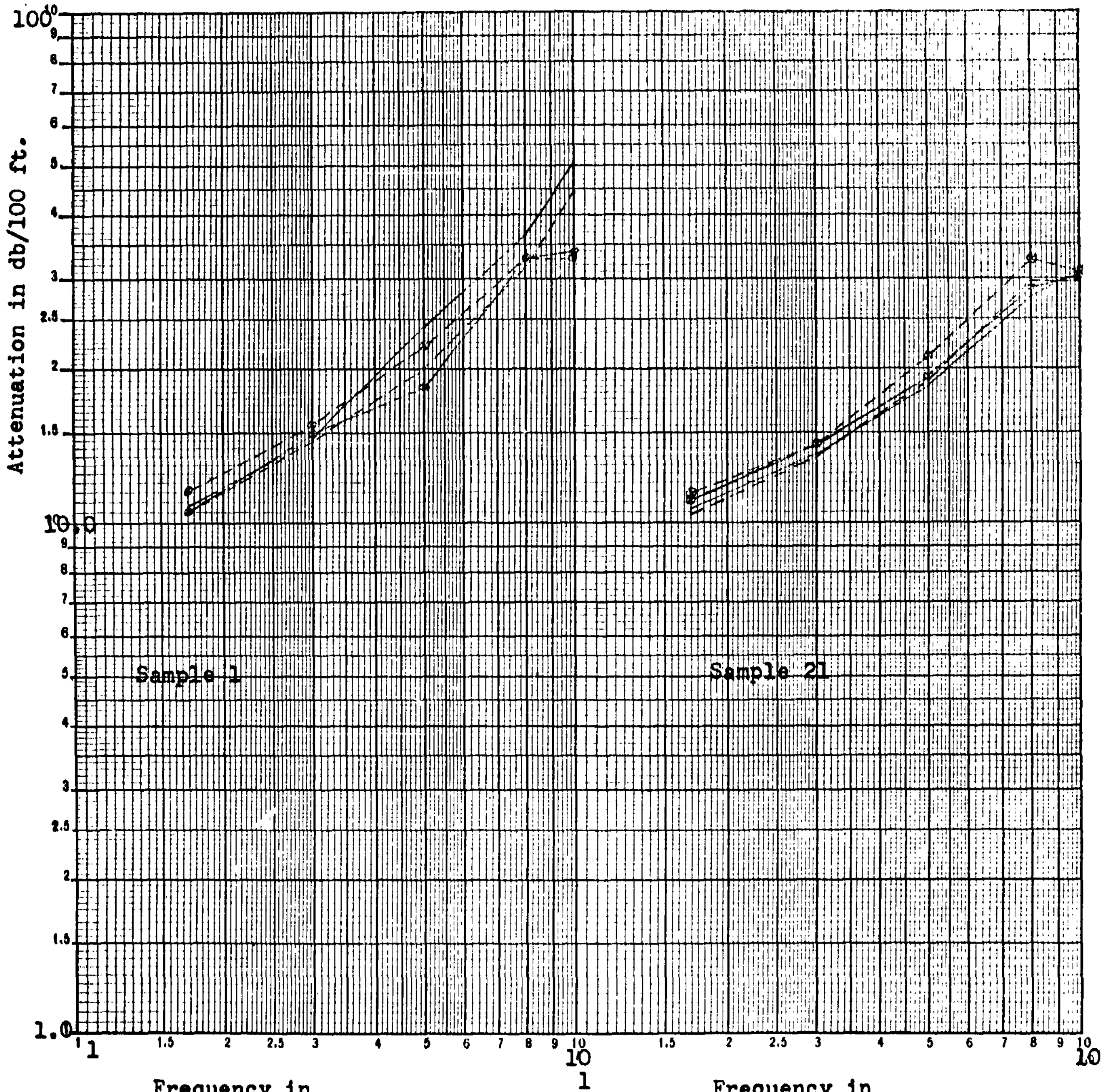


Graph 1.47 - Attenuation stability test results on samples 7 and 20.



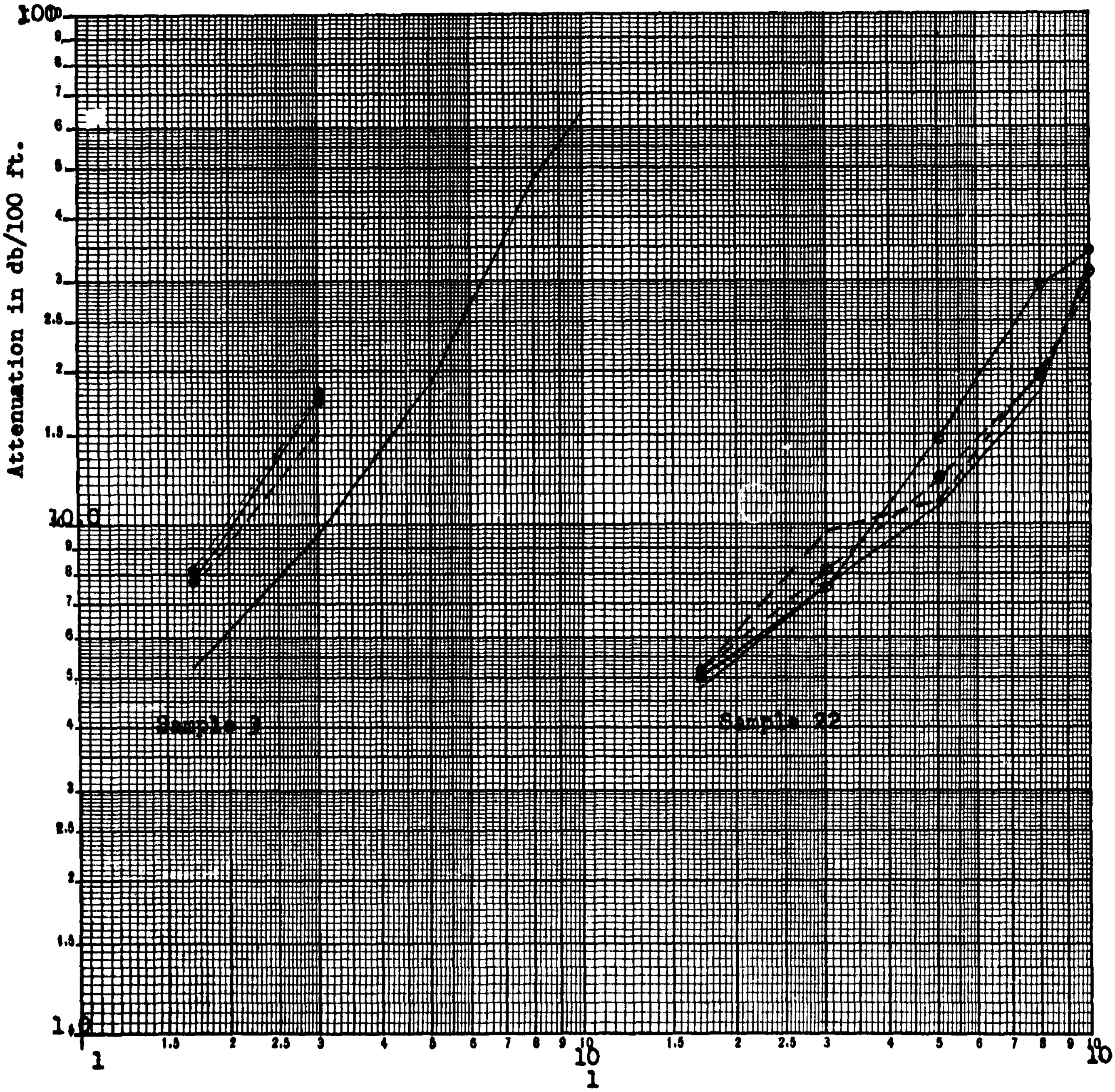
Graph 1.48 - Attenuation stability test results on samples 1 and 21.

KEY
_____after manufacture
x - x after heat aged
------ after flex
x ---x after cold bend



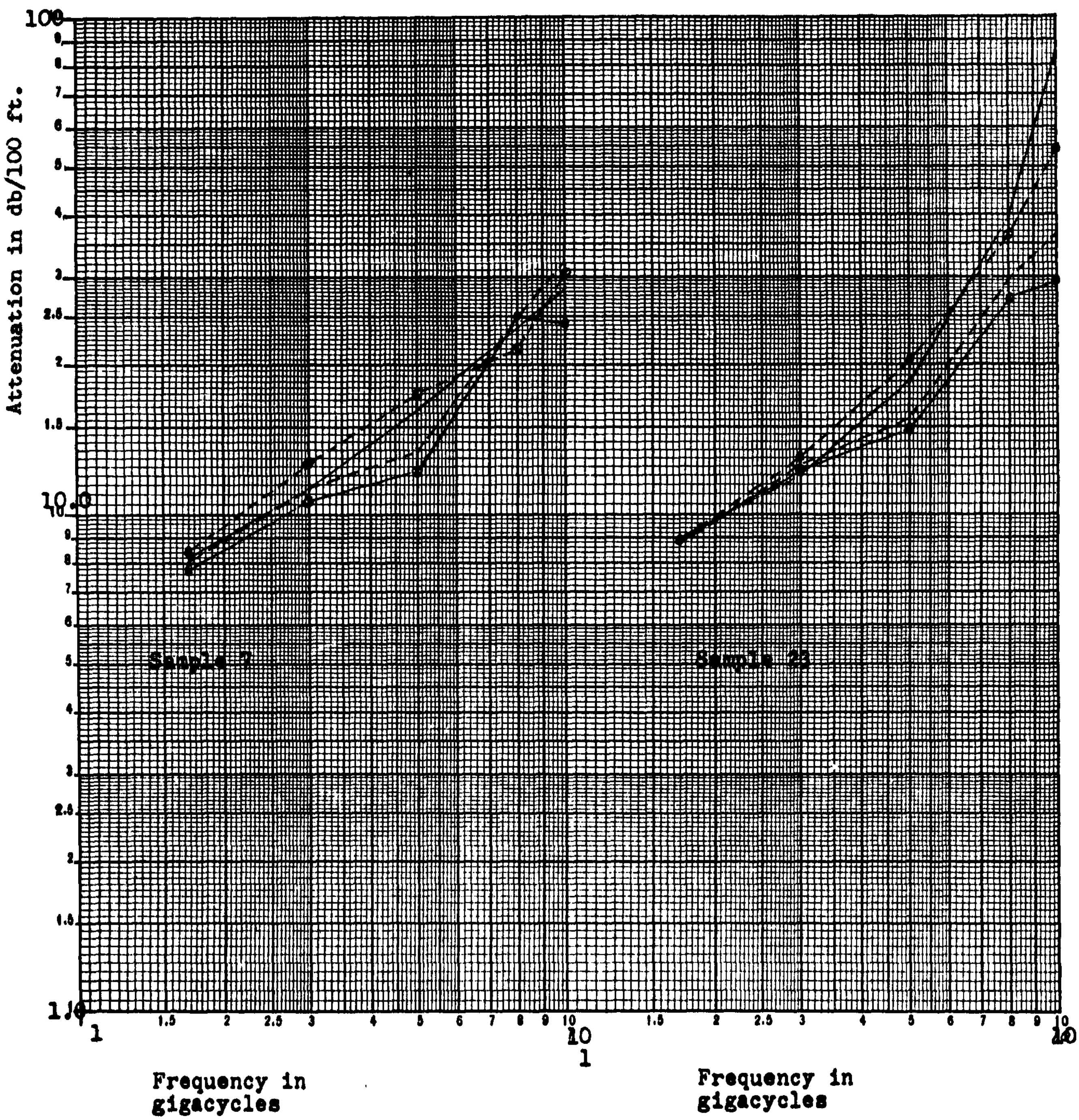
Graph 1.49 - Attenuation stability test results on samples 3 and 22.

KEY
—— after manufacture
x --x after heat aged
----- after flex
x --x after cold bend



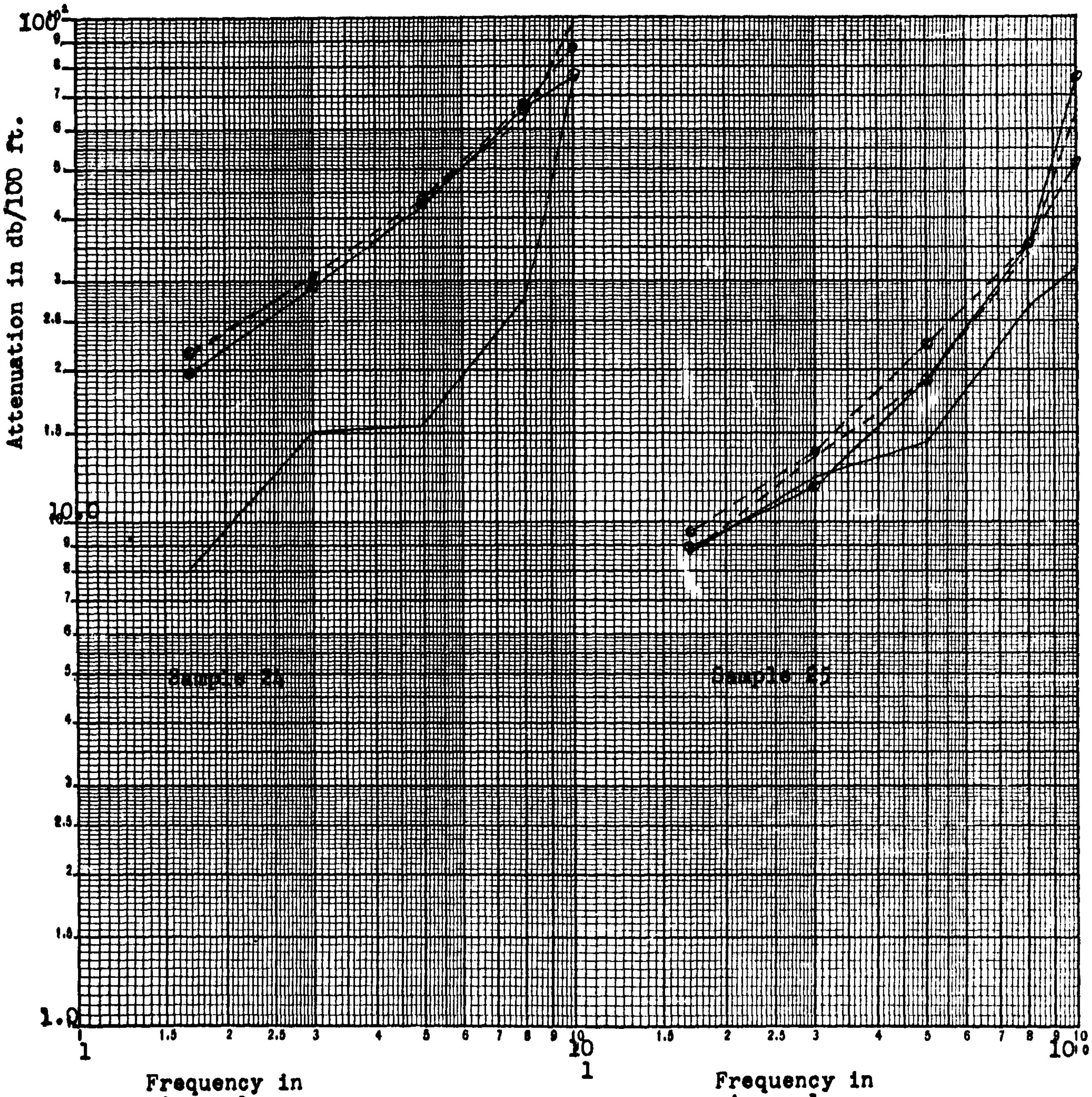
Graph 1.50 - Attenuation stability test results on samples 7 and 23.

KEY
—— after manufacture
x - x after heat aged
----- after flex
x---x after cold bend



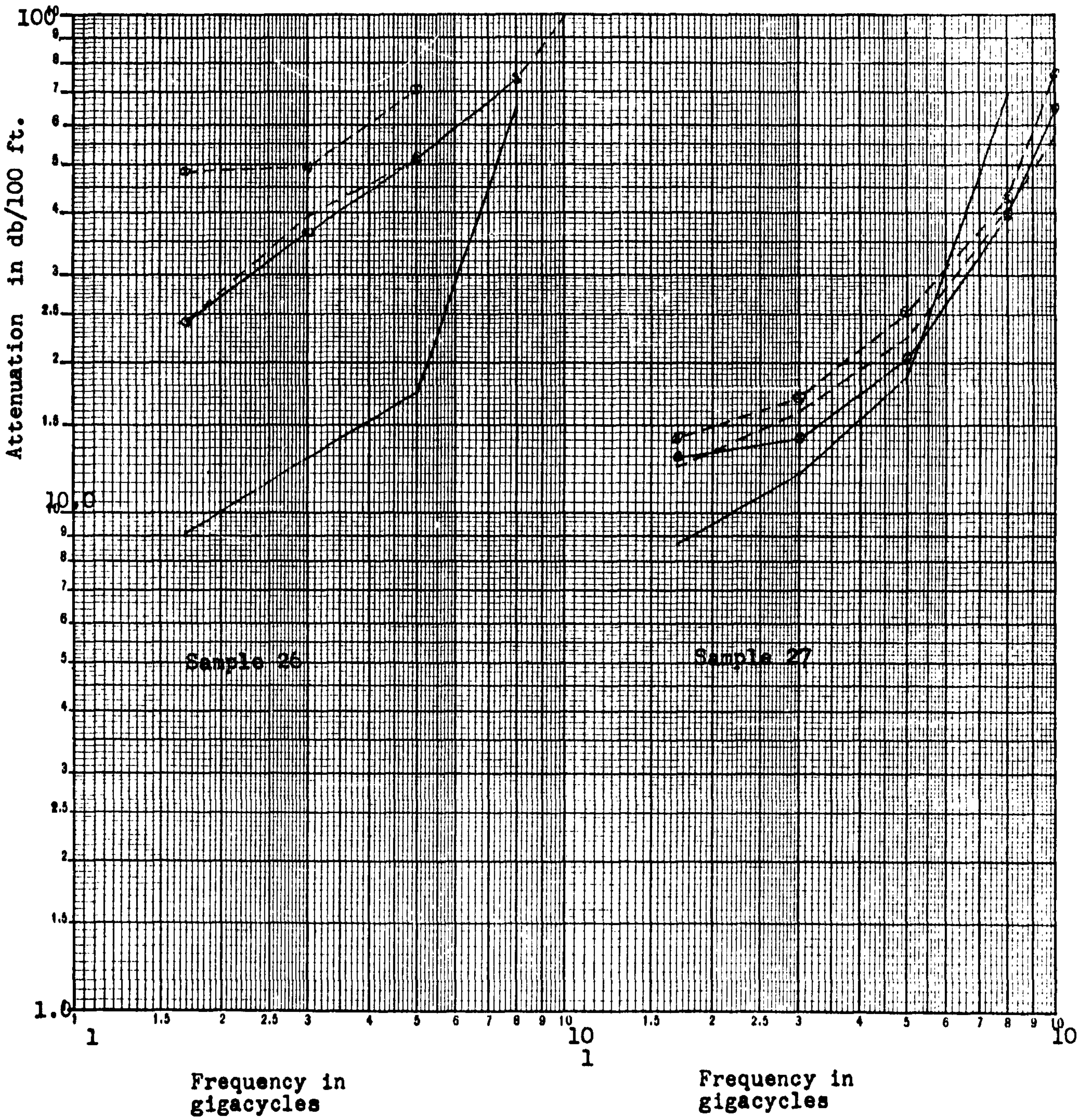
Graph 1.51 - Attenuation stability test results on samples 24 and 25.

KEY
——— after manufacture
x —x after heat aged
--- after flex
x --x after cold bend



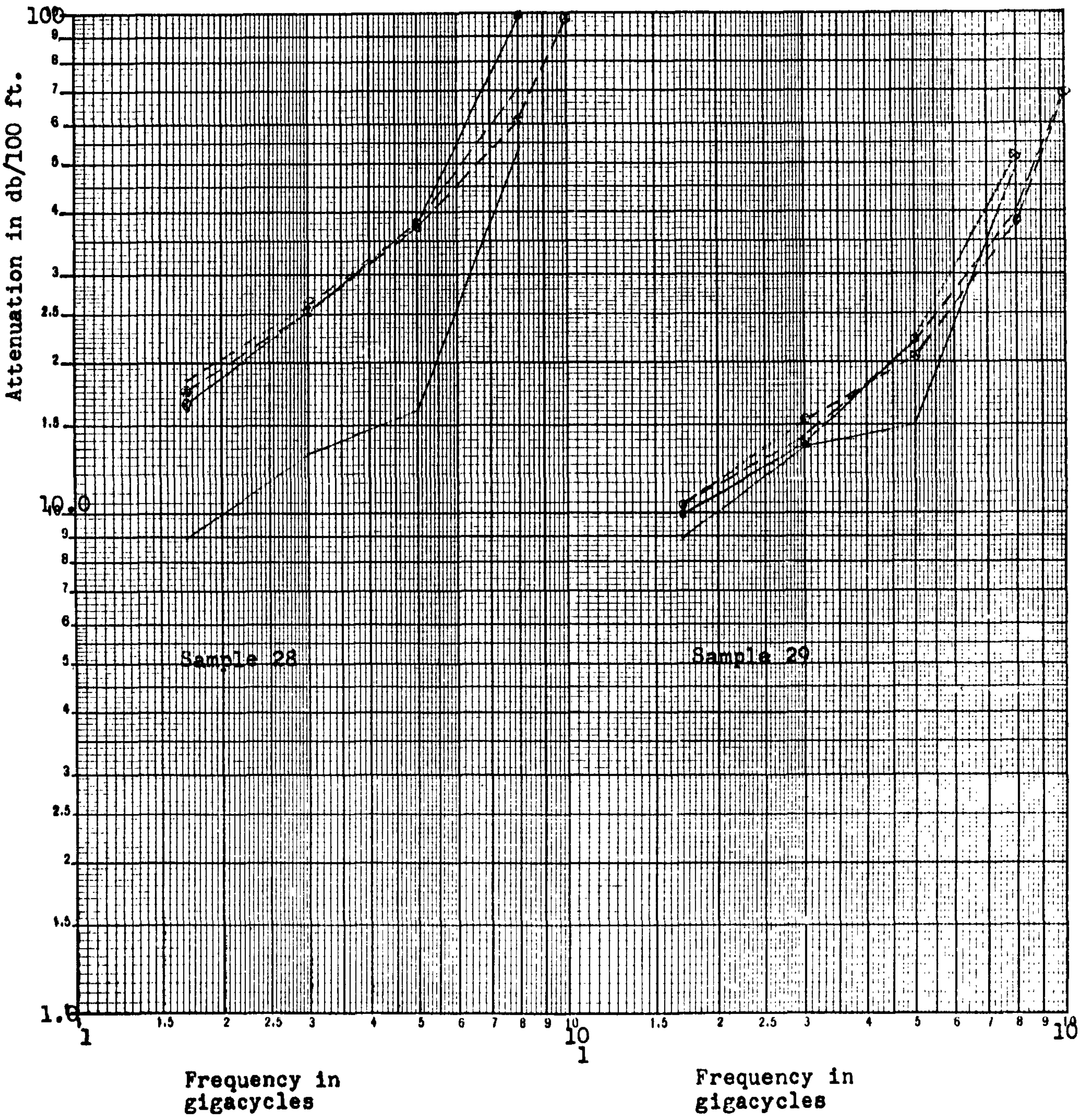
Graph 1.52 - Attenuation stability test results on samples 26 and 27.

KEY
——— after manufacture
x - x after heat aged
------ after flex
x---x after cold bend



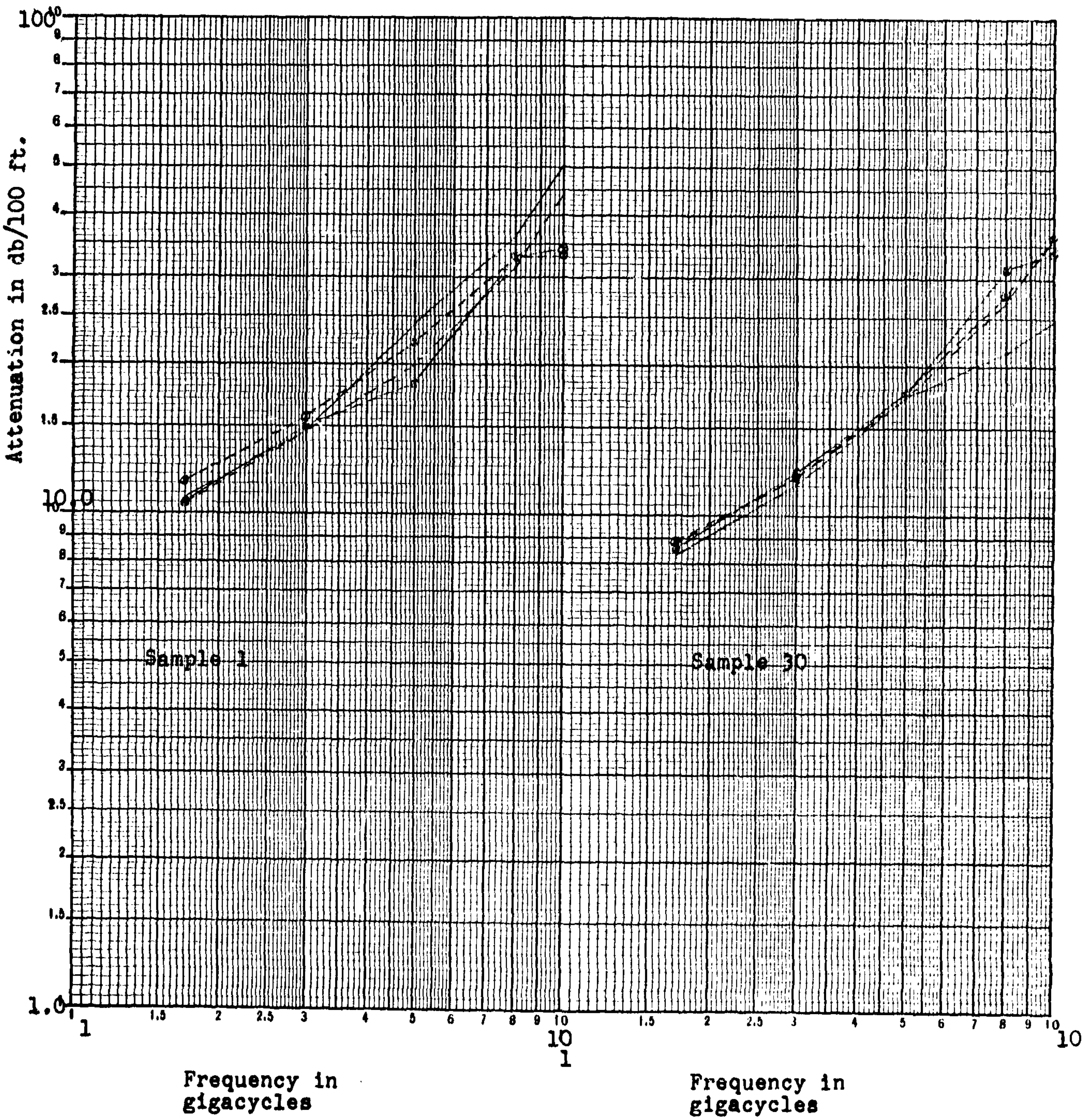
Graph 1.53 - Attenuation stability test results on samples 28 and 29.

KEY
—— after manufacture
x - x after heat aged
- - - after flex
x -- x after cold bend



Graph 1.54 - Attenuation stability test results on samples 1 and 30.

KEY
——— after manufacture
x --x after heat aged
---- after flex
x --x after cold bend



1.3.9 Watertightness test results - Table 1.5, this page, lists the watertightness test results after manufacture and after conditioning on samples 4, 5 and 6.

1.3.10 Discussion of watertightness test results - The watertightness results show the techniques for making a cable with a solid center conductor and a diameter of less than 500 mils over the braid is acceptable for 1000 psi applications but the technique to watertight stranded center conductors and the techniques used on larger cables must be improved. A stranded center conductor increases a cable's attenuation and really does not make the cable more flexible because of the stiffness of the jacket. Improving the watertighting techniques on this type construction, however, should be investigated because the techniques used on solid center conductor cables make the cables watertight at pressures greater than 2500 psi but the smooth solid center conductor extrudes out of the core on short lengths. The stranded center conductor might improve this bond strength. Attempts to watertight without the tape over the braid should be investigated since cable could be manufactured with a smoother jacket if the polyethylene tape could be eliminated.

Table 1.5 - Watertightness Test Results

Sample	After Manufacture	After Conditioning
4	100 psi for 1 hr, no leakage 200 psi for 2½ hrs, no leakage 300 psi for 2 hrs, no leakage 400 psi for ½ hr, no leakage 500 psi for 1 hr, no leakage *500 psi for 15 hrs, 1 cc	100 psi for 1 hr, no leakage 200 psi for 1 hr, no leakage 300 psi for 1 hr, no leakage 400 psi for 40 mins, 20 cc
5	100 psi for 1 hr, no leakage 200 psi for 1 hr, no leakage 500 psi for 2 hrs, no leakage 1000 psi for 2 hrs, no leakage 1000 psi for 2 hrs, no leakage	100 psi for ½ hr, no leakage 500 psi for 2 hrs, no leakage 1000 psi for 2 hrs, no leakage
6	**100 psi for 30 mins, 10 cc	leaked immediately

*pressure dropped to 160 psi during time, leakage occurred around center conductor.

**pressure dropped to 0 psi during time, leakage occurred through braid.

1.3.11 Flammability test results - Table 1.6, pages 71 and 72, lists the flammability test results.

1.3.12 Discussion of flammability test results - The results show that all the jacketing materials burn or melt but the polyvinyls are self extinguishing while polyethylene and polyurthane jackets are not self extinguishing. The results also indicate the noncontaminating polyvinylchloride is a little harder to ignite than the standard type polyvinylchloride (about same to ignite as polyethylene) but the standard type extinguishes itself sooner.

Table 1.6 - Flammability Test Results

Sample	Time to ignite (min-sec)	Time to extinguish (min-sec)	Type of smoke	Flame Travel (inches)	Jacket material
1A B C	2:10 2:07 2:45	1:50 2:03 2:00	Black smoke and soot	3.00 3.00 2.50	noncontaminating polyvinylchloride
2A B C	2:02 2:11 2:07	1:57 2:06 2:04	Black smoke and soot	2.75 2.50 2.50	noncontaminating polyvinylchloride
3A B C	1:45 2:05 1:58	1:50 2:00 2:01	Black smoke and soot	2.50 2.50 2.50	noncontaminating polyvinylchloride
4A B C	1:45 2:05 1:59	----	Light smoke and soot	Entire length of sample	polyethylene
5A B C	2:04 2:10 2:09	----	Light smoke and soot	Entire length of sample	polyethylene
6A B C	2:18 2:10 2:13	----	Light smoke and soot	Entire length of sample	polyethylene
7A B C	1:58 2:08 2:10	----	Light smoke and soot	Entire length of sample	polyethylene
8A B C	2:05 1:58 2:10	----	Light smoke and soot	Entire length of sample	polyethylene
10A B C	2:21 2:05 2:14	----	Light smoke and soot	Entire length of sample	polyethylene
11A B C	2:09 2:11 2:03	----	Light smoke and soot	Entire length of sample	polyethylene
12A B C	1:55 1:43 2:01	----	Light smoke and soot	Entire length of sample	polyethylene
13A B C	2:14 2:06 2:17	----	Light smoke and soot	Entire length of sample	polyethylene
15A B C	2:10 2:15 2:06	----	Light smoke and soot	Entire length of sample	elastomeric polyethylene
17A B C	2:06 1:51 1:45	----	Light smoke and soot	Entire length of sample	polyethylene
18A B C	1:20 1:30 1:28	----	Light smoke and soot	Entire length of sample	polyurthane

Table 1.6 - Flammability Test Results (cont.)

Sample	Time to ignite (min-sec)	Time to extinguish (min-sec)	Type of smoke	Flame travel (inches)	Jacket material
20A B C	2:17 2:09 2:07	----	Light smoke and soot	Entire length of sample	elastomeric polyethylene
21A B C	2:01 2:16 2:03	----	Light smoke and soot	Entire length of sample	polyethylene
22A B C	1:57 1:58 2:11	----	Light smoke and soot	Entire length of sample	polyethylene
23A B C	2:17 2:13 2:03	----	Light smoke and soot	Entire length of sample	polyethylene
24A B C	1:10 1:10 1:07	0:53 1:11 0:59	Black smoke and soot	2.50 2.50 2.25	polyvinylchloride
25A B C	2:06 2:25 2:10	1:48 2:05 1:30	Black smoke and soot	3.00 2.25 2.50	noncontaminating polyvinylchloride
26A B C	1:06 1:15 1:12	0:35 0:56 1:15	Black smoke and soot	2.00 2.50 2.50	polyvinylchloride
27A B C	2:06 2:25 2:10	1:55 2:05 2:10	Black smoke and soot	2.25 3.00 2.50	noncontaminating polyvinylchloride
28A B C	1:08 1:23 1:12	0:51 0:45 1:01	Black smoke and soot	2.25 2.50 2.00	polyvinylchloride
29A B C	1:45 2:00 2:45	2:10 1:50 1:40	Black smoke and soot	2.00 2.50 3.00	noncontaminating polyvinylchloride
30A B C	2:04 2:10 2:07	1:58 1:56 2:01	Black smoke and soot	2.25 2.25 2.25	noncontaminating polyvinylchloride

1.3.13 Other test results - The results of the dimensional measurements, capacitance, impedance, cold bend, abrasion and corona test results are listed in Table 1.7, pages 73 and 74.

1.3.14 Discussion of other test results - The abrasion results must be compensated for jacket wall thickness and braid construction but the results show an outstanding abrasion resistance for polyurthane. The abrasion resistance test on polyethylene was meaningless as the wax like material filled the abrasive rods and then would not wear because of its low coefficient of friction. Several samples failed the cold bend test but a pattern of failure was not established.

Table 1.7 - Other test results

Sample		Dimensions: Cond. O.D.	Dimensions: Dielectric O.D.	Dimensions: Jacket O.D.	Dimensions: Jacket Thickness	Diel. Conct.	C	Vg.	Z	Cold Bend	Abras. Resis.	Corona I	Corona E
	a	7/.0297	.2840-.2840	.416-.427	.033-.044	94.9%	30.75	66.2	50.0		1047	15	13.3
1	b	7/.0292	.2840-.2850	.411-.422	.034-.044	91.7%	30.85	66.0	50.0	failed	1098	15	13.2
	c	7/.0296	.2840-.285C	.415-.420	.034-.044	96.6%	30.85	66.0	50.0		1075	14	12.2
	a	.1060	.3690-.3682	.538-.549	.051-.064	95.6%	30.30	66.3	50.6		454	15.0	13.0
2	b	.1060	.3710-.3712	.537-.545	.051-.062	95.1%	30.40	66.3	50.5	failed	512	15.0	12.0
	c	.1060	.3693-.3713	.539-.547	.051-.063	95.1%	30.30	66.4	50.4		542	14.5	11.0
	a	.1960	.6722-.6810	.852-.877	.061-.068	81.9%	30.60	66.5	49.9		181	715	
3	b	.1960	.6700-.6790	.852-.870	.070-.074	81.8%	30.70	66.5	49.8	passed	197	715	
	c	.1960	.6720-.6790	.873-.893	.069-.080	83.3%	30.50	66.4	50.2		219	715	
	a	7/.0292	.2872-.2920	.417-.434	.035-.047	84.3%	31.20	65.6	49.6			8.9	6.5
4	b	7/.0290	.2930-.2982	.425-.431	.039-.050	83.0%	31.10	65.8	49.7	passed		9.0	6.0
	c	7/.0290	.2850-.2940	.424-.438	.038-.045	83.0%	31.10	65.6	49.7			9.6	6.4
	a	.1050	.3738-.3770	.536-.544	.060-.064	91.7%	30.45	66.0	50.5			15	
5	b	.1049	.3732-.3771	.533-.546	.059-.065	90.2%	30.55	65.7	50.8	passed		15	
	c	.1050	.3700-.3761	.543-.550	.061-.064	87.7%	30.45	65.7	50.9			15	15
	a	.1960	.6720-.6850	.856-.873	.066-.084	92.5%	31.10	66.2	49.4			15	
6	b	.1958	.6670-.6790	.851-.871	.063-.079	91.9%	31.10	65.5	49.8	failed		15	
	c	.1953	.6720-.6820	.856-.867	.061-.082	95.3%	31.10	66.2	49.4			15	
	a	.1060	.3646-.3650	.539-.551	.071-.082	81.6%	30.65	66.9	49.6			3.0	2.0
7	b	.1065	.3639-.3689	.534-.547	.073-.086	82.2%	30.65	66.5	49.9	failed		3.0	2.0
	c	.1065	.3650-.3677	.532-.541	.066-.082	83.9%	30.75	66.5	49.8			3.2	2.8
	a	.1058	.3614-.3687	.545-.552	.074-.086	79.0%	30.80	66.4	49.7			3.8	3.0
8	b	.1058	.3611-.3702	.543-.555	.078-.082	78.0%	30.85	66.5	49.6	passed		3.6	3.1
	c	.1060	.3620-.3680	.540-.550	.081-.093	80.0%	30.75	66.3	49.9			3.6	3.0
	a	19/.0232	.3700-.3768	.539-.552	.070-.086	89.0%	31.90	66.2	48.2			13.0	7.8
10	b	19/.0230	.3710-.3770	.538-.546	.071-.083	87.2%	31.90	66.1	48.2	failed		12.5	9.2
	c	19/.0230	.3700-.3790	.536-.545	.075-.085	88.3%	31.90	66.2	48.2			13.6	8.2
	a	Braided	.3524-.3923	.525-.557	.071-.083	93.5%	29.05	69.8	50.2			3.6	2.8
11	b	.1054	.3573-.3765	.523-.552	.070-.086	89.0%	29.95	68.8	49.4	passed		3.6	2.8
	c	-.1121	.3572-.3674	.521-.554	.068-.084	83.0%	29.95	68.6	49.4			3.4	2.8
	a	Braided	.3509-.3697	.536-.548	.081-.098	95.0%	23.70	68.7	62.6			3.8	3.2
12	b	.0820	.3307-.3745	.531-.555	.070-.092	88.0%	23.40	68.4	63.5	passed		3.8	3.3
	c	- .0843	.3580-.3770	.531-.563	.081-.091	89.0%	23.70	68.2	62.9			3.9	3.3
	a	.1052	.2950-.2970	.469-.477	.077-.088	70.2%	24.20	82.5	57.0			4.6	3.0
13	b	.1054	.2840-.2880	.434-.481	.074-.087	73.5%	24.70	81.9	50.4	passed		4.0	3.0
	c	.1053	.2920-.2980	.472-.481	.079-.089	69.3%	24.50	81.9	50.8			4.0	3.1
	a	.1060	.3630-.3690	.531-.537	.074-.083	83.9%	38.00	61.9	43.2			14.6	10.6
15	b	.1059	.3700-.3790	.531-.540	.072-.085	82.2%	37.60	62.0	43.6	passed		14.4	9.4
	c	.1060	.3650-.3690	.532-.535	.072-.080	81.6%	37.60	62.0	43.7			14.0	10.8
	a	.1061	.3630-.3645	.490-.498	.058-.068	85.2%	31.10	66.7	49.1			3.8	3.6
17	b	.1060	.3630-.3660	.490-.498	.057-.061	82.8%	30.60	66.8	49.9	passed		3.2	2.9
	c	.1060	.3632-.3672	.489-.498	.057-.062	83.3%	30.60	66.9	49.7			3.2	2.8

Table 1.7 - Other test results

Sample		Dimensions: Cond. O.D.	Dielectric O.D.	Jacket O.D.	Jacket Thickness	Diel. Conct.	C	Vg.	Z	Cold Bend	Abras. Resis.	Corona I	Corona E
	a	.1061	.3651-.3730	.541-.546	.065-.085	84.5%	30.40	67.0	49.9			3.5	3.0
18	b	.1065	.3685-.3712	.544-.552	.069-.092	81.7%	30.40	66.8	50.1	passed	over	3.2	2.7
	c	.1061	.3660-.3740	.532-.548	.069-.085	81.0%	30.50	66.5	50.1		10,000	3.3	2.9
	a	.1060	.3580-.3690	.539-.542	.073-.086	83.2%	30.80	66.6	49.6			3.7	2.9
20	b	.1060	.3590-.3660	.536-.541	.075-.094	83.2%	30.80	66.9	49.2	passed		3.5	2.9
	c	.1060	.3579-.3670	.534-.541	.077-.087	79.9%	30.90	66.9	49.2			3.3	2.8
	a	7/.0290	.2840-.2850	.400-.403	.047-.050	88.5%	30.80	66.2	49.8			14.8	10.2
21	b	7/.0292	.2840-.2850	.400-.406	.048-.051	83.6%	30.70	66.1	50.1	passed		15.0	11.4
	c	7/.0291	.2840-.2850	.402-.406	.046-.050	83.9%	30.70	66.5	49.8			12.8	10.2
	a	.1960	.6710-.6782	.822-.853	.066-.067	92.0%	30.45	66.4	50.2			7.8	4.0
22	b	.1960	.6755-.6870	.825-.849	.067-.068	93.3%	30.55	66.4	50.2	passed		7.6	3.8
	c	.1960	.6772-.6878	.823-.842	.063-.069	92.1%	30.65	66.2	50.0			7.6	4.8
	a	.1065	.3663-.3673	.536-.552	.067-.090	83.2%	30.80	66.2	49.8			3.4	2.8
23	b	.1065	.3660-.3689	.538-.550	.068-.087	83.0%	30.70	66.0	50.2	failed		3.2	2.8
	c	.1067	.3620-.3650	.533-.551	.067-.087	81.9%	30.80	66.2	49.8			3.1	2.7
	a	.1060	.3700-.3703	.536-.546	.067-.081	83.1%	30.60	66.5	50.0		over	3.4	2.8
24	b	.1059	.3670-.3686	.539-.548	.072-.084	82.3%	30.50	66.7	50.0	failed	5,000	4.0	3.0
	c	.1060	.3670-.3691	.534-.546	.070-.087	83.2%	30.40	66.5	50.3			3.5	2.9
	a	.1059	.3649-.3662	.542-.548	.074-.087	83.0%	30.70	67.0	49.4		528	3.5	3.0
25	b	.1060	.3653-.3663	.542-.552	.074-.087	85.8%	30.70	66.8	49.6	failed	502	3.5	2.9
	c	.1062	.3640-.3650	.535-.542	.071-.083	84.0%	30.70	66.5	49.8		542	3.7	2.9
	a	.1062	.3702-.3715	.543-.549	.070-.088	80.7%	30.30	66.5	50.5		over	3.2	2.8
26	b	.1060	.3700-.3720	.543-.552	.070-.088	85.7%	30.20	66.5	50.5	failed	5,000	3.1	2.7
	c	.1062	.3691-.3735	.545-.553	.070-.087	83.3%	30.30	66.5	50.5			3.1	2.7
	a	.1060	.3660-.3720	.548-.554	.073-.085	81.5%	30.40	66.5	50.3		291	4.0	3.0
27	b	.1064	.3670-.3710	.542-.550	.073-.085	80.9%	30.50	66.7	50.1	failed	238	3.2	2.7
	c	.1065	.3670-.3720	.543-.550	.073-.084	83.2%	30.50	66.4	50.2		307	3.5	3.0
	a	.1060	.3707-.3721	.539-.548	.069-.081	80.5%	30.30	66.3	50.6		over	3.0	2.8
28	b	.1055	.3718-.3757	.543-.553	.068-.084	82.2%	30.20	66.4	50.7	failed	5,000	3.2	2.8
	c	.1061	.3730-.3741	.544-.553	.067-.085	84.7%	30.20	66.5	50.6			3.2	2.7
	a	.1066	.3610-.3730	.542-.554	.075-.087	81.2%	30.60	66.6	49.9		3483	4.6	3.0
29	b	.1064	.3682-.3693	.541-.550	.073-.085	82.8%	30.60	66.5	50.0	failed	3631	3.9	2.9
	c	.1062	.3686-.3690	.543-.552	.074-.085	83.7%	30.60	66.5	50.0		3514	3.1	2.8
	a	7/.0293	.2830-.2840	.416-.424	.052-.056	85.2%	30.65	66.4	49.9		409	15.0	12.0
30	b	7/.0293	.2850-.2860	.417-.420	.055-.063	89.1%	30.65	66.2	50.0	passed	385	14.1	10.8
	c	7/.0293	.2830-.2840	.422-.428	.054-.063	87.3%	30.75	66.4	49.8		391	15.0	13.3

1.3.15 Pliability test results - Table 1.8, this page, liststhe pliability test results

table 1.8 - Pliability test results

Bend Temperature	80°F		0°F		-40°F			
Sample	weight (lbs)	time (sec)	weight (lbs)	time (sec)	weight (lbs)	time (sec)	Jacket *Mat.	Jacket Dia.
1	1	16	7	28	8	35	NCPVC	.425
2	4	35	9	74	too stiff		NCPVC	.545
5	4	45	9	75	too stiff		Poly	.545
7	4	30	9	58	too stiff		Poly	.545
8	4	26	10	47	too stiff		Poly	.450
10	4	29	10	42	too stiff		Poly	.545
11	4	35	9	63	too stiff		Poly	.545
12	4	41	9	72	too stiff		Poly	.545
13	4	32	9	63	too stiff		Poly	.475
15	4	34	10	42	too stiff		EPoly	.545
17	4	35	10	61	too stiff		Poly	.500
18	4	30	4	39	4	57	Urt	.545
20	4	28	10	47	too stiff		EPoly	.545
21	4	29	10	38	too stiff		Poly	.405
22	15	40	36	78	too stiff		Poly	.850
23	4	58	8	86	10	77	Poly	.545
24	4	35	9	70	too stiff		PVC	.545
25	4	56	8	69	too stiff		NCPVC	.545
26	4	43	8	59	too stiff		PVC	.545
27	4	31	9	61	too stiff		NCPVC	.545
28	4	28	9	40	too stiff		PVC	.545
29	4	18	9	29	too stiff		NCPVC	.545
30	4	31	9	31	too stiff		NCPVC	.425

*NCPVC - noncontaminating polyvinylchloride
PVC - polyvinylchloride
Poly - polyethylene
EPoly - elastomeric polyethylene
Urt - polyurethane

1.3.16 Discussion of pliability test results - The pliability test results show the pliability of a cable, at the present state of the art, depends mostly upon the jacketing material. The results on sample 18, compared to results on other samples, show polyurethane is more pliable than any of the other material tested. The effect of solid vs stranded conductor, stranded braid vs ribbon braid is hidden by the stiffness of the polyethylene jacket. The effect might be noticeable on samples with polyurethane jacket. The results also show the polyurethane jacketed sample was not much stiffer at -40°F than it was at 80°F.

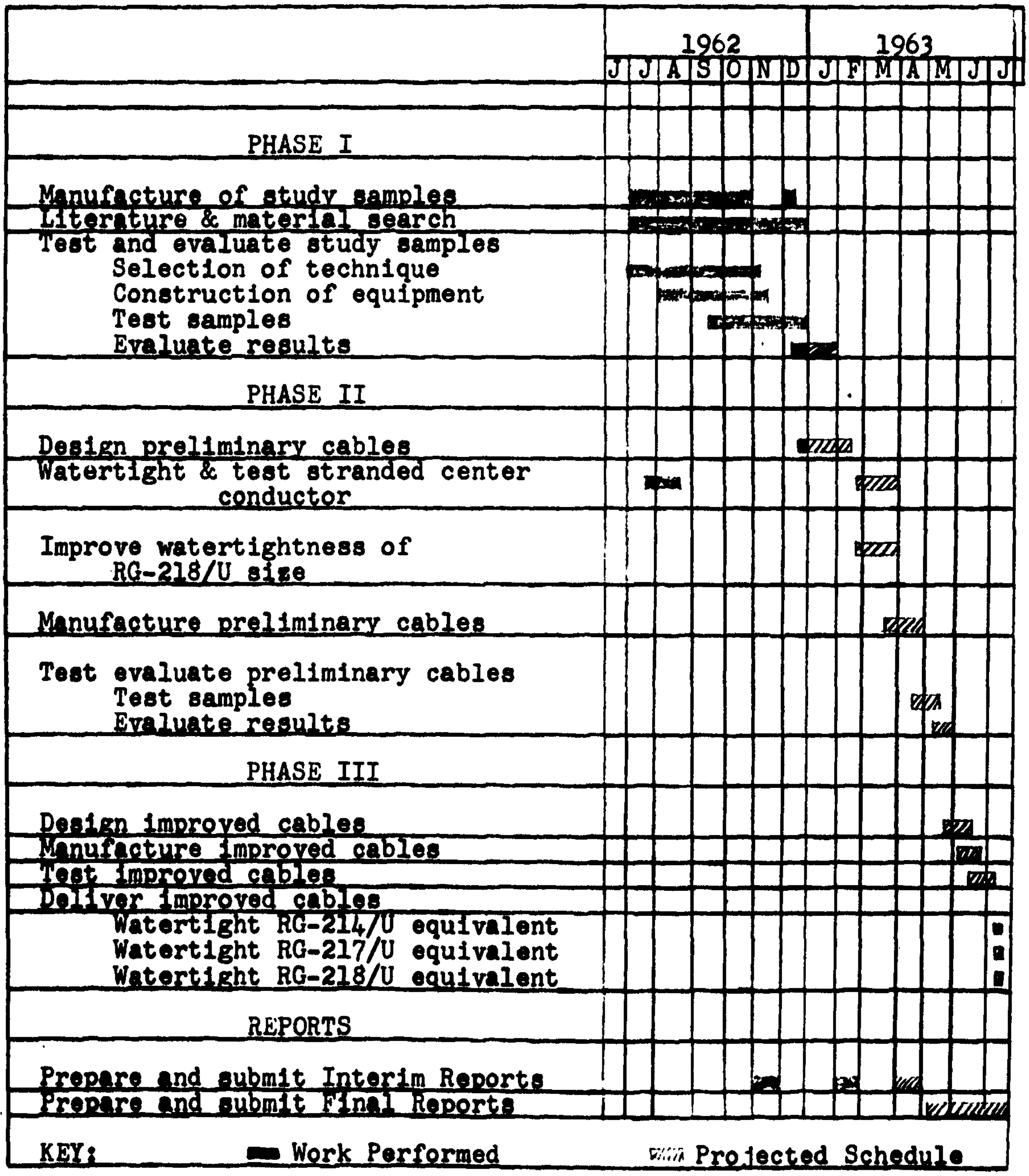
TIMES WIRE AND CABLE DIVISION
International Silver Company

1.3.17 PROJECT PERFORMANCE AND SCHEDULE
Project Serial No. SF0060306, Task 2266

Contract No. : NObsr-87678

Date: March 1, 1963

Period covered - 10/1/62 to 12/31/62



1.4 CONCLUSIONS

1.4.1 General conclusions - While the results are not completely evaluated it can be concluded that with slight design changes all three cable types can be manufactured watertight at 1000 psi and have decreased attenuation, decreased size, more abrasion resistance and greater flexibility.

1.4.2 Conclusion from attenuation test results - The attenuation of RG-214/U, RG-217/U, and RG-218/U can be slightly decreased across the frequency range of 10 MC to 10 GC by designing to a minimum braid factor and can be decreased considerably by using a flat ribbon braid. The high frequency attenuation can be greatly improved by using silver plated braid strands.

1.4.3 Conclusion from watertightness test results - All the cables can be manufactured watertight at 1000 psi if RG-214/U is redesigned with a solid center conductor. Since a solid center conductor tends to extrude out of the dielectric core at higher pressures it is necessary to continue to improve the watertighting techniques on stranded center conductors in the hope the stranded conductor will have better bond strength to the core and produce watertight cables at even higher pressures.

1.4.4 Conclusion from abrasion resistance test results - A polyurethane jacket has vastly better abrasion resistance than any of the other jacketing materials investigated. The size of the cable can be decreased by using a thinner wall of polyurethane and still have greater abrasion resistance than cables manufactured with the usual wall thickness of polyethylene and polyvinylchloride.

1.4.5 Conclusion from pliability test results - While polyethylene jacketed cables are more pliable at room temperatures and cold temperatures than polyvinylchloride jacketed cables, a polyurethane jacket yields a cable that is much more pliable at all temperatures.

PART II

2.1 PROGRAM FOR NEXT INTERVAL

2.1.1 Phase I

2.1.1.1 Evaluate test results on study samples - The test results presented in this report will be completely evaluated during the first portion of the next reporting period.

2.1.2 Phase II

2.1.2.1 Design of preliminary cables - All preliminary cables will be designed and manufacturing will be started.

2.1.2.2 Improve watertightness - Techniques will be perfected for making stranded center conductors watertight. Techniques will also be perfected to make RG-214/U and RG-218/U watertight at 1000 psi. The techniques will be similar to those used to make RG-217/U watertight at 1000 psi. Advance cable designs similar to RG-214/U, RG-217/U and RG-218/U will be manufactured in an attempt to make cable watertight at 2500 psi.

2.1.3 Schedule - The schedule for this program is given in the Project Performance and Schedule Chart of page 76.

III APPENDIX

APPROVAL SHEET

TIMES WIRE & CABLE DIVISION

THE INTERNATIONAL SILVER COMPANY,

358 Hall Avenue

Wallingford, Connecticut

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